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A SUMMARY OF THE USERS PERSPECTIVE OF LANDSAT-D AND

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A SUMMARY OF THE USERS' PERSPECTIVE

OF

LANDSAT-D

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(Updated)

January 31, 1977

SUMMARY OF
USERS' PERSPECTIVE

PREFACE

The authors acknowledge the significant contributions of Daniel D. Richard (Office of User Affairs), James V. Zimmerman (Office of International Affairs), and Barbara E. Williams (on temporary assignment to the Office of User Affairs from IBM through the Presidential Interchange Executive Program).

TABLE OF CONTENTS

A SUMMARY OF THE USERS' PERSPECTIVE OF LANDSAT-D

REFERENCE SECTION OF LANDSAT USERS

1.0 INTRODUCTION AND SUMMARY

During the past twelve months, NASA conducted a comprehensive analysis of the potential applications and need for a Landsat-D mission. All sectors of the user community, including federal agencies, state, regional and local governments, and private industry, participated in evaluating the needs for and benefits to be derived from a continuing Landsat program. In addition, the commercial suppliers of Landsat-related equipment and services were asked to address the questions of present and future markets and the possible effects on projected sales assuming various decisions related to a continuing program.

NASA's efforts to obtain the views of the public and private sectors were extensive, and included: (1) contracted surveys and studies of user needs and evaluations of possible Landsat system characteristics; (2) personal contacts with users including phone calls, visits, and briefings; (3) confidential Landsat data and equipment suppliers market survey; (4) presentations at various symposia; (5) an open briefing concerning Landsat-D possibilities to industrial suppliers; and (6) the establishment of a Federal Interagency Decision Team composed of Assistant Secretaries/Administrators of U.S. Departments of the Interior (USDI), Agriculture (USDA), Commerce (USDC), Army Corps of Engineers (COE), Agency for International Development (AID), and NASA. These efforts resulted in formal documentation in the form of reports, letters, interview notes, and minutes of meetings, which constitute the users' views of Landsat technology and the value of a continuing program such as would be provided by the proposed Landsat-D system.

It was the consensus of all users that the Federal Government has developed a technology that has the potential to provide widespread societal and economic benefits at a time when resource scarcities and management practices are paramount on the list of growing national concerns. There was also consensus that the Federal Government should guarantee a Landsat data source in the future and that the overall benefits to the nation exceed the cost.

State, regional, and local governments generally stated that the data should be considered in the same context as census, cartographic, and meteorological data which are provided to the public as a service by the Federal Government. Both the National Governors Conference and the National Conference of State Legislatures resolved that NASA should develop the Landsat-D system as proposed. The system as proposed by NASA was considered responsive to state needs. The improved capabilities of the Thematic Mapper was of utmost importance to land inventory applications, particularly in the urban setting, enabling the extraction of increasingly detailed information concerning a greater number of land categories. In addition, the state users stated that the Federal Government should make a firm commitment to insure the operational status of the Landsat system and to develop a systematic and effective technology transfer process to include user assistance and training. It is significant that the states felt it was also their responsibility to share in the overall costs of developing the technology transfer process and adopting Landsat as an operational data source.

The private industrial suppliers of Landsat-related equipment and services projected a $1B-$4B market over the next 10 years for products and services directly associated with Landsat data reception and analysis, excluding satellite hardware. It was pointed out that the corporate taxes alone on the profits generated through these sales may help to repay a portion of the government's cost for Landsat-D. Some of the larger companies have already invested a few million dollars in market development. All of the companies are reluctant to more aggressively pursue the market because of the risk caused by the uncertainty of a continuous data source. This "uncertainty" has contributed to fragmenting the marketplace. Users need assurance of a continuous data source before they will make financial commitments; industry wants to reduce its risk and to have a growth market before it will make front-end investments. The industrial suppliers further stated that a decision now by the Federal Government to provide a data source only through 1983 would moderately reduce their projected market, and that a three year disruption in the source of data (1980-1983) would reduce their sales by 70-90%.

The private users in the mineral and petroleum industries unanimously agreed that Landsat-D would greatly increase their efficiency in locating valuable new deposits and would significantly reduce their costs for geological and geophysical exploration. It was further concluded that the benefits to the petroleum and mineral industries most probably will be in the multi-millions of dollars per year. It is apparent, however, that these benefits will be more quantitatively determined as their research continues through the Landsat-C time period. The timber industry identified some potential benefits in forest inventory and overall resource management, but generally felt that more research and development was needed before they would commit to the operational use of Landsat data. The greater resolution provided by the Thematic Mapper is a must for both the timber industry and the mineral and petroleum industries. The increased spectral sensitivity and coverage of the Thematic Mapper was also considered critical in order to accurately discriminate timber species, some rock types, and surface artifacts. A repetitive and systematic information data base was a major requirement.

The federal user community's views were expressed through the Interagency Decision Team (IDT). The IDT strongly supported Landsat-D to provide sufficient time to conduct a test to determine its operational utility and system effectiveness. Federal agencies are already expending considerable effort to experiment with the use of Landsat data to better conduct their missions, and some have entered into demonstration and transfer projects to develop sufficient information to warrant a go/no go decision to adopt Landsat remote sensing technology operationally. The IDT recommended in a signed statement that NASA be given approval in its FY 1978 budget to develop the Landsat-D system as proposed.

In summary, the user communities identified in this report strongly support a Landsat-D system. They conclude that the Federal Government has already demonstrated the potential benefits to both public and private sectors from

the use of Landsat data and has stimulated enthusiasm throughout the world for what Landsat can provide in the future. Even U.S. foreign relations have benefited from Landsat as is evidenced by AID's active involvement in Landsat technology. International lending institutions use Landsat routinely to assist base mapping, resource development, and construction efforts. With this background and the strong support for Landsat-D as evidenced by letters and reports from all sectors of the user community, it is NASA's conclusion that overwhelming user support exists for the Landsat-D program in the FY 1978 budget.

The remainder of this summary report provides a synopsis of the opinions of the major user communities: (a) federal, (b) state, regional and local, and (c) private industry, relative to the need for, and value of an improved Landsat-D system. Each of these user groups is summarized by sector in terms of its demand for Landsat data, present and potential applications, need for and impact of an improved satellite capability represented by Landsat-D, and a general evaluation of the benefits accrued to each group as a result of Landsat use. The interests of these three user sectors is also presented on a multisector/application basis in a brief summary of the studies performed by the Application Survey Groups (ASG's) and the survey completed by the Battelle Columbus Laboratories. In addition, a brief discussion concerning the rapidly growing interest and use of Landsat in foreign nations is provided.

The summary report is followed by a detailed Reference Section of Landsat Users. This section contains the various letters, resolutions and other statements made by user organizations in expression of their opinion concerning the Landsat program. References in the summary report, e.g., Letter II–C (9-1), refer to individual user statements contained in the reference document. To avoid confusion, it is also important to emphasize that any underlining of quoted statements is that of the individual quoted and not the author of this document.

2.0 FEDERAL USERS

One of the most important user elements in the Landsat earth resources satellite program is the federal sector. Aside from the acquisition of satellite data, which has been the responsibility of NASA and the U.S. Geological Survey, up to this point, executive agencies are extremely interested in Landsat data to serve their own information needs and to provide data to their constituencies.

In order to cooperatively identify and resolve issues relating to the development of future earth resources satellites, an Interagency Decision Team (IDT) was established consisting of NASA, the Departments of Agriculture, Commerce and the Interior, the Corps of Engineers and the Agency for International Development. Each agency was represented at the Administrator or Assistant Secretary level. To support the IDT, a technical level Working Group was also formed. The IDT served on this basis to obtain and formally reference federal requirements for Landsat-D and to evaluate Landsat-D characteristics.

The main purpose of the IDT was to consider the evolutionary direction of the earth resources satellite program and to recommend the next step to be taken. The IDT felt that by the end of the useful life of Landsat-C (about 1980), sufficient demonstration and verification of Landsat-derived benefits would have accrued to warrant a test of an operational system. While none of the agencies are currently ready to commit to operational use of Landsat data, there was consensus that the government should conduct a three-to-six year validation test of a system which would have the major elements anticipated for any fully operational capability of the future.

The IDT addressed three major issues in considering its recommendations for the earth resources satellite program after Landsat-C:

(1) Federal User Agency Requirements for Landsat Data - Each agency was asked to identify its current and future needs for satellite data.

(2) Technical Characteristics - The IDT Working Group and the IDT reviewed alternative proposals for satellites, sensors, and ground systems which would best meet those needs identified.

(3) Policy Considerations - Most of the IDT's work addressed the roles and responsibilities of the respective agencies in the program and other policy questions such as the pricing structure for the data and opportunities for commercial involvement in the data processing system.

The positions of the IDT-member agencies are summarized below. This material summarizes the discussion and documentation which was incorporated in the minutes of the IDT and IDT Working Group meetings.

2.1 Agency for International Development - AID carries out the U.S. foreign aid program and, in recent years, has placed heavy emphasis on providing scientific and technical assistance to its client countries. Because of the growing international interest in the Landsat program, AID strongly supports its continuation and expansion. AID's main concern, as expressed in the IDT, is that any future Landsat systems be compatible with the current one so that those foreign nations who are building or operating ground stations will not be forced to invest a major amount of additional funds. Accordingly, AID supported the continued use of a Landsat-C-type Multispectral Scanner and an associated telemetry and data handling system. AID is also concerned that there is continuity of these data so that foreign ground stations continue to receive revenues. The Administrator of AID urged that an early decision be made on the commitment to an operational program so that foreign nations can rely on long term availability of Landsat data. AID does desire the higher resolution Thematic Mapper data to evaluate its utility for mapping agricultural assessments and other uses.

2.2 Department of Agriculture The USDA is potentially the most important federal user of Landsat data because of the possible economic benefits to the nation from improved information on global agriculture. The results of the Large Area Crop Inventory Experiment (LACIE) have indicated that crop forecasting based on satellite data could be a cost/effective method for obtaining worldwide agricultural information. USDA reported to the IDT that it had identified approximately 250 departmental information requirements for Landsat data for both the current and proposed sensors. While existing Landsat data is adequate for wheat inventories in North America and the USSR, improved resolution is needed for fields in India, China, and other countries and to measure other major crops. In addition to crop forecasting, the Forest Service, Agricultural Research Service (Letter IA), Statistical Reporting Service and Soil Conservation Service are all using Landsat data and want to experiment with the Thematic Mapper.

For many applications, USDA would find useful to have a nine day coverage capability (2 satellites in orbit) to increase the likelihood of obtaining cloud free data. However, this was not identified as a critical requirement particularly if the 18-day coverage requirement is met.

USDA is very concerned about continuity of Landsat data. It is possible that a satellite-based global wheat inventory system could be operating by 1980. Investment in such a system would only be approved if there was reasonable certainty of continuous data availability.

USDA also specified a need for improvements in the ground data handling facilities so that digital or photographic products are provided within five days of acquisition. USDA's own data distribution facility at Salt Lake City would continue to provide Landsat data products to the public.

2.3 Department of Commerce - The National Oceanic and Atmospheric Administration (NOAA) will continue to use Landsat data primarily as a research tool. NOAA is interested in using Landsat for studies of coastal processes and shoreline measurements, flood assessments, environmental effects of petroleum and mineral exploration in the outer continental shelf and for snow cover estimations. In addition, the Census Bureau is very interested in using satellite imagery to delineate urban boundaries as an aid to its census surveys. The Census Bureau believes that the 30-meter resolution Thematic Mapper data will greatly contribute to this capability.

2.4 U.S. Army Corps of Engineers - The Corps plans to continue its extensive use of Landsat data and feels that the increased spatial and spectral resolution of the Thematic Mapper will better serve its needs than the current Multispectral Scanner. The Corps is considering the possibility of having its own digital processing system to take Landsat data directly from the acquisition facility and process it into useful products.

The Corps plans to use Landsat data increasingly as a decision making tool; it will establish regional service bureaus to assist local districts. Among the applications cited by the Corps are:

- o Hydrology
  - Surface water and snowmelt/runoff estimation
  - Environmental Assessments
  - Flood plain and inundation assessment
- o Construction
  - Geological studies
  - Cultural features
  - Soil Surveys
- o Coastal Studies
  - Bottom features near harbors and inlets
  - Sediment transport
- o Regulatory function
  - Wetlands monitoring

2.5 Department of the Interior - The Department of the Interior has a major interest in Landsat because of its vast resource management responsibilities. Interior has been evaluating Landsat's utility for strip mine monitoring, wildlife habitat monitoring (Letter IB), rangeland assessments, land use planning and for environmental baseline assessments for energy development. Interior strongly favors continued use of the Multispectral Scanner for most of these studies at least until the Thematic Mapper is completely proven.

The Department of the Interior has been especially concerned about its continued responsibility for data dissemination to the public; this includes reproduction, archiving, and distribution of the data, along with training and assistance for the users. The IDT worked out solutions to a number of problems associated with the increased data load from the Thematic Mapper on Interior's Sioux Falls facility.

Interior supports the view, adopted by the IDT, that long term operating costs of the Landsat program must be offset by revenues from data sales. This will necessitate a substantial increase in data prices. The IDT also agreed that opportunities for commercialization of the data distribution function should be explored so that, if appropriate, government could move out of this area and let private industry develop it.

Aside from the IDT-member organizations, several federal agencies have used or plan to use Landsat data for a variety of purposes. The Defense Mapping Agency has already used Landsat imagery to update hydrographic charts and is extremely interested in the additional spectral bands of the Thematic Mapper which will aid in shallow water bathymetry. The Environmental Protection Agency has experimented with remote sensing for various environmental monitoring tasks. According to an EPA news release (76-24), "multispectral scanning is now regarded as a technique offering great potential for lake nutrient surveillance." EPA also wants to experiment with Thematic Mapper data for monitoring ocean dumping and other sources of pollution.

Other agencies who may use Landsat are the Federal Highway Administration, for engineering geology; the Energy Research and Development Administration, for geologic studies, mineral exploration and thermal effluent monitoring; the Department of Justice, for surveillance of illegally grown drugs; and the Tennessee Valley Authority, for general land use and hydrologic studies.

3.0 STATE, REGIONAL AND LOCAL USERS

3.1 Approach

There were three major activities directed toward identifying and evaluating the present and potential applications and benefits, as well as the need for an improved Landsat-D program in the state, regional and local user community. They consisted of the following:

- o Evaluation by the National Conference of State Legislatures (NCSL) of the value of an improved Landsat program in satisfying the legislative and programmatic information requirements of state government.

- o Evaluation of the perceived value of the present and proposed Landsat program to state needs through personal contact with resource mangers in numerous user organizations including multi-state regional groups, individual states and substate entities such as regional, county and city governments.

- o Evaluation by Washington University of the required capabilities of Landsat-D to meet state data needs which could possibly not be met by the Landsat I and II capabilities.

These activities were designed to obtain a factual assessment from the users' perspective. This section summarizes the results of this assessment on the basis of the following: (a) states' data demand; (b) key Landsat experience and applications; (c) need for and impact of improved capabilities; and (d) benefits derived from the use of Landsat data by the states.

3.2 Data Demand

In recent years, both state and federal legislation have increased the authority and responsibility of state governments for management of natural resources and land use. In many areas, states are taking the initiative in developing an active role by the creation of policy and programs for land, environmental and resource management. The aggregate results of the legislative trends is significant in that it places the prime responsibility for decision-making relative to the nation's environment, natural resources and land planning squarely on the states (see for example the list of current and pending legislation in Tables 3-1 and 3-2).

To successfully execute these responsibilities, states require increasingly large and diversified quantities of data on a recurring basis. Presently available information does not satisfy these growing needs and conventional data collection techniques are often too costly (see Letters II-C (17-2) and II-B (1)).

TABLE 3-1

LEGISLATIVE AND PROGRAMMATIC IMPETUS

FEDERAL LEGISLATION/PROGRAMS	(FUNDING $ MILLIONS)
• HUD 701 COMPREHENSIVE PLANNING ASSISTANCE PROGRAM - 1968	175 (FY 75 & 76)
• EPA 203 AREAWIDE PLANNING AND WASTE TREATMENT - 1972	203 (" ")
• COASTAL ZONE MANAGEMENT (CZM) ACT - 1972	38 (" ")
• LAND AND WATER CONSERVATION ACT - 1965	176 (FY 76)
• PUBLIC WORKS AND ECONOMIC DEVELOPMENT ACT - 1965	120 (")
• APPALACHIAN REGIONAL DEVELOPMENT ACT - 1965	200 (")
• WATER POLLUTION CONTROL ACT - 1972	65 (")
• WATER RESOURCES PLANNING ACT (ESTABLISHMENT OF RIVER BASIN COMMISSION) - 1965	
• NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) - 1969	
• HUD FLOOD INSURANCE PROGRAM - 1968	
• FOREST AND RANGELAND RENEWABLE RESOURCES PLANNING ACT - 1974	
• ASSISTANCE FUND FOR COASTAL IMPACT OF OIL AND GAS DEVELOPMENT IN OUTER CONTINENTAL SHELF - 1976	
• NATIONAL DAM INSPECTION PROGRAM - 1972	
• SOLID WASTE UTILIZATION AND MANAGEMENT ACT - 1976	
• CLEAN AIR ACT - 1970	
• RURAL DEVELOPMENT ACT - 1972	
• WATER RESOURCES DEVELOPMENT ACT - 1974	

17

STATE LEGISLATION/PROGRAMS

- LAND USE AND ENVIRONMENT RELATED
  - COMPREHENSIVE LAND USE PLANNING (21 STATES--e.g, OREGON LAND CONSERVATION AND DEVELOPMENT ACT)
  - COASTAL ZONE MANAGEMENT (15 STATES--e.g., CALIFORNIA COASTAL ZONE CONSERVATION ACT)
  - SURFACE MINING (32 STATES--e.g., NEW YORK STATE MINED LAND RECLAMATION ACT)
  - CRITICAL AREAS DESIGNATION (10 STATES--e.g., MINNESOTA CRITICAL AREAS ACT)
  - POWER PLANT SITING (29 STATES--e.g., MARYLAND POWER PLANT SITING ACT)

- RESOURCE MANAGEMENT
  - FORESTRY
  - WATER RESOURCES
  - AGRICULTURE
  - FISH AND WILDLIFE

  LONG STANDING STATE LEGISLATION

13

TABLE 3-2

PENDING FEDERAL LEGISLATION

- ENERGY FACILITIES PLANNING AND DEVELOPMENT ACT
- LAND RESOURCES PLANNING ASSISTANT ACT
- LAND USE AND RESOURCE CONSERVATION ACT
- STATE AND LOCAL GOVERNMENT FISCAL ASSISTANCE RENEWAL
- NATIONAL FOREST MANAGEMENT ACT
- FEDERAL COAL LEASING AMENDMENTS ACT
- CLEAN AIR ACT AMENDMENTS
- AMENDMENT OF COASTAL ZONE MANAGEMENT ACT TO STUDY IMPACT OF ENERGY RESOURCE DEVELOPMENT
- SURFACE MINING CONTROL AND RECLAMATION
- OUTER CONTINENTAL SHELF LAND ACT AMENDMENTS AND MANAGEMENT ACT
- SOLID WASTE DISPOSAL ACT AMENDMENTS
- SOLID WASTE ENERGY AND RESOURCE RECOVERY ACT
- WATER POLLUTION CONTROL ACT AMENDMENTS

It is the judgement of state resource managers that Landsat is an important tool in satisfying this new and heavy data demand, and in many cases, is uniquely capable to obtain the data coverage required to carry out the intent of the legislation. This judgement is reflected in the following statement in the NCSL Final Report, identifying a prime legislative use of remote sensing (Landsat) as:

> " - - - a means of collecting data for programs whose data requirements have gone unmet due to accessibility, cost or time constraints."

This capability of Landsat in meeting current user needs is also emphasized in the following statement made by Mr. Ted Haines from the Southwestern Illinois Regional Planning Commission during the NCSL Task Force Hearings on Landsat:

> "Landsat is the only method which is timely, inexpensive and fulfills the federal requirements which now confront (the regional planning commissions)"

3.3 Key Landsat Experience

The public sector considers Landsat as an important new technology that is presently, and will continue to make significant contributions to the information base required to satisfy legislation and improved resource management goals. This consensus is based on nearly four years of involvement by a variety of state, regional and local government agencies in the research and development, and application of Landsat derived information to their program requirements. As a result of this experience, these users believe that Landsat provides a necessary tool to address present and future problems in a cost effective, comprehensive, timely and accurate manner- see Letters II-C (12-1), II-C (17-2) and II-B (1).

The most important and widespread Landsat application was found to be the generation of land cover inventory data which are integrated and combined with supplemental information such as economic, demographic and ownership data to develop a geobased resource information system. The use of Landsat data as a compatible and easily updated component of an information system and as an input to computer modeling was found to be a rapidly developing tool for resources management and land use planning. Most of these developing uses are based upon the increasing information needs of legislation, the lack of existing data and the high costs and limitations of conventional techniques. As an example, North Dakota is developing the Regional Environmental Assessment Program (REAP) in response to a legislative mandate to provide an environmental baseline against which to measure the impact of increased coal mining in the state. The following statements by Dr. A. William Johnson, Director of REAP typifies much of the present and future directions and activities in state resource management (Letter II-C (14-1)).

"Within the last two months the North Dakota Regional Environmental Assessment Program has made a major financial and programmatic commitment for the long-term utilization of LANDSAT information as a cornerstone of our geobased statewide environmental assessment system."

"Specifically, we now have in force $1.2 million worth of contracts with a variety of organizations for the acquisition and gathering together of baseline data in the general subject areas of air quality-meteorology, animals, geology, historic-archaeologic-paleontologic sites, land cover analysis, social impact, socio-economic impact, soils, vegetation, and water. One of these contracts, totaling approximately $140,000 is for a complete land cover analysis of the State of North Dakota using 1974 and 1975 LANDSAT imagery."

The states of Texas, South Dakota, Georgia and Ohio are several additional examples of states which are using Landsat as a key source for information system development.

Nearly all the state users define the basic value of Landsat as its capability to view and inventory surface cover on a recurring basis. This land cover information is being utilized in nine basic program areas. These nine program areas are delineated below along with examples of Landsat applications and some using organizations as references.

(1) Land Use Planning, Management and Development

- o Inventory of statewide and regional land cover and monitoring of change
  - North Dakota Regional Environmental Assessment Program (REAP) - Letter II-C (14-1)
  - South Dakota Planning Bureau - Letter II-C (17-2) - Ohio Environmental Protection Agency and Department of Natural Resources - Letter II-C (15-2) and (15-3)
- o Site and route selection
  - Tennessee Valley Authority - Letter II-B (3)
  - North Dakota REAP (in concert with Basin Electric Power cooperative) - Letter II-C (14-1)
- o Monitoring of urban land use and of urban fringe growth
  - Los Angeles County Department of Regional Planning - Letter II-D (4-1)
  - Ada County Government, Idaho (emphasis on vacant lands) - Letter II-B (2)

- Development of multidisciplinary data base for land capability/suitability analysis

  - Hawaii Department of Planning and Economic Development - Letter II-C (8-2) - Tennessee Valley Authority - Letter II-B (3)

(2) Critical Areas Management

- Delimitation of saltwater and freshwater species of plant life for wetlands identification

  - Georgia Bureau of Planning and Budget, and Department of Natural Resources - Letter II-C (7-1)
  - Louisiana Department of Highways - Letter II-C (11-2) from Louisiana Executive Department

- Coastal zone management to include inventory of coastal resources, potential land uses, change monitoring and identification of endangered environments

  - Texas General Land Office - presentation at NCSL hearing on Landsat
  - Georgia Department of Natural Resources - Letter II-C (7-2)

- Detection of erosion of coastal areas, littoral current flows, saltwater intrusion

  - Louisiana Water Resources Research Institute - Letter II-C (11-7)
  - Alabama Geological Survey - Report II-C (1-3)

(3) Environmental Monitoring

- Delimitation of land cover and identification of non-point sources of potential pollution for the Environmental Protection Agency Section 208-Areawide Waste Treatment Program

  - Ohio Department of Environmental Protection - Letter II-C (15-2)
  - Georgia Water Protection Division, Department of Natural Resources - Letter II-C (7-2)
  - Ohio-Kentucky-Idaho (OKI) Regional Council of Governments (see page 53 - Final NCSL Report on State Use of Satellite Remote Sensing, August 25, 1976.

- o Monitoring of environmental impacts of development, e.g., increased water sediment load
  - Georgia Department of Natural Resources - Letter II-C (7-2)
- o. Evidence in legal suit to protect natural environment and water supply
  - Florida Office of the Attorney General - Letter II-C (6-4)
- o Selection of sanitory landfill sites for solid waste disposal
  - Georgia Land Protection Division, Department of Natural Resources - Letter II-C (7-2)
- o Land reclamation from various disruptive uses
  - Maryland Geological Survey, Department of Natural Resources - Letter II-C (12-2)
- o Monitoring of construction and operation of deepwater port and related onshore facilities to determine impact of pipeline construction and operation, e.g., saltwater intrusion, sheet flow interruption, subsidence and turbidity
  - Louisiana Offshore Terminal Authority - Letter II-C (11-4)

(4) <u>Energy Related Programs</u>

- o Inventory of strip mined lands
  - Maryland Geological Survey, Department of Natural Resources - Letter II-C (12-2)
  - Missouri Geological Survey, Department of Natural Resources - Letter II-C (13-1)
- o Geologic mapping to include tectonic boundaries, lithologic contacts, foliation trends, topographic lineaments and faults
  - Alabama Geological Survey - Letter II-C (1-3)
  - Georgia Department of Natural Resources - Letter II-C (7-2)

- o Broaden effectiveness of mineral exploration
  - Missouri Department of Natural Resources - Letter II-C (13-1)

(5) Water Resources Management

- o Detection and mapping of surface water and impoundments
  - Texas Water Rights Commission - Letter II-C (19-1)
  - Wisconsin Department of Natural Resources - Letter II-C (23-1)
- o Flood plain mapping and flooded area assessment
  - North Dakota Water Commission (visit with Mr. LeRoy Klaphrocht, Water Commission)
  - Louisiana State Planning Office - Letter II-C (11-3)
- o Monitoring of irrigated lands and assessment of water needs
  - Idaho Department of Water Resources - Letter II-C (9-1)
  - Oregon Department of Water Resources - Letter II-C (16-1)
- o Interpretation of groundwater hydrology
  - Alabama Geological Survey - Letter II-C (1-5)
  - Georgia Department of Natural Resources - Letter II-C (7-2)
- o Mapping of vegetation habitats for purposes of watershed protection and flood prevention
  - Georgia Department of Natural Resources - Letter II-C (7-2)
- o River and drainage basin inventories
  - Missouri Department of Conservation - Letter II-C (13-1)
  - North Dakota Water Commission (visit with LeRoy Klaphrocht Water Commission)
- o Analysis of lake eutrophication trends
  - Wisconsin Department of Natural Resources - Letter II-C (23-1)

(6) Forestry Management

- o Inventory of forest reserves, estimate of timber production, detection of diseased stands, and monitoring of forest practices

  - Washington State Department of Natural Resources - Letter II-B (2)
  - Alabama Development Office - Letter II-C (1-3)

(7) Fish and Wildlife

- o Determination of suitable lands for wildlife habitat assessment

  - Oregon Department of Fish and Wildlife - Letter II-B (2)
  - Texas Parks and Wildlife (visit with Sam McCullough, Texas Natural Resources Information System)

(8) Agricultural Monitoring

- o Monitoring location and spread of infestation

  - Oregon Department of Agriculture - Letter II-B (2)

- o Generalized soil association mapping, salinity detection

  - Missouri Department of Natural Resources - Letter II-C (13-1)
  - Kern County Water Agency, California - Letter II-D (3-1)

- o Soils/land capability mapping for tax assessment

  - South Dakota State Planning Bureau with Remote Sensing Institute of South Dakota (visit with Paul Tessar, South Dakota State Planning Bureau)

(9) Transportation Facilities Planning

- o Delineation of lineaments and faults for geologic substructure evaluation and sinkhole detection

  - Florida Department of Transportation - Letter II-C (6-13)

- Evaluation of water blockage resulting from highway construction leading to removal of impediments to free water exchange

  - Louisiana Department of Highways - Letter II-C (11-5)
  - Florida Department of Transportation - Letter II-C (6-13)

- Provision of up-to-date indicators of land use changes

  - Florida Department of Transportation - Letter II-C (6-13)

3.4 Need For and Impact Of Improved Capability

In assessing the need for improved capabilities such as those represented by Landsat-D, the state user community evaluated three different aspects of the Landsat program: (1) data distribution system; (2) technology transfer activities; and (3) the technical system performance characteristics of the Landsat system. In performing this analysis, the users emphasized that from a "real world" users' point of view the Landsat program must be evaluated in its effectiveness as a total system from data acquisition to the development of a useful product.

3.4.1 Data Distribution and Project Development System

There were three basic improvement areas identified relating to data distribution and product development. The first and the one most often identified was the need for a commitment by the Federal Government to insure Landsat data continuity. The using state agencies have strictly operational characteristics and feel that they must be assured of the availability of data if they are to make significant investments and program adjustments to rely on Landsat as a continuing data source. This need is reflected by the following statement from the Southern Growth Policies Board - Letter II-B(1):

> "A commitment to data continuity represented by the Landsat Follow-on program would encourage resource managers and user agencies in the member states of the SGPB to have confidence in the duration of the Landsat program and result in an increased conversion to and use of Landsat data to meet their legislative and programmatic needs."

The need for data continuity was also one of the prime conclusions of the Landsat program evaluation by the National Conference of State Legislatures (NCSL) as stated in the following recommendation from the NCSL Final Report:

"Congress should make a firm commitment to insure the operational status of the satellite-based data system. This commitment is necessary for states to be able to invest in the technology transfer steps necessary for statewide 'operational use' of this system. It would also assure the building of a continuous data base for monitoring and change detection purposes."

"The states should take the responsibility of providing some form of support for this system."

It was continually emphasized by all the users contacted that the states will not make a significant investment in equipment and services unless they are assured that a continuous data source will be available.

The second improvement area was the need for increased data timeliness and ease of access and availability. There needs to be more emphasis on improved and systematic communication to state users describing the quality as well as format of available Landsat data and the procedures necessary to obtain it. For example, a critical piece of information (presently unavailable) for the user purchasing Landsat data is the location of cloud cover within a Landsat scene in addition to the percent of the total frame it covers. The user needs to know whether or not his area of interest is cloud-free before he makes a decision to purchase Landsat data.

The users also felt that the present time duration from data acquisition to receipt of data is excessive and intolerable for many applications, especially disaster monitoring. If a using organization is dependent on Landsat data for a regulatory monitoring function, it requires the most timely transmittal of information possible to implement corrective action.

The third area of improvement identified is the need for development of low cost techniques, equipments and standardized final products for state use. If additional emphasis was placed on low-cost development, an increased breadth of users would be able to utilize Landsat. It is the users' opinion that the aggregation of the benefits resulting from the additional use of Landsat by these "low budget" organizations would be significant. The NCSL Final Report emphasized the need for further development of the low-cost approach in its final recommendations as follows:

"Both the private sector and universities should be encouraged to attempt development of effective inexpensive data products for state use. However, (federal) funding for the research and development of such products should be funneled through the states to insure the development of products most useful to state needs."

3.4.2 Technology Transfer

There is a unanimous feeling among state users that a strong federal commitment to a systematic and on-going technology transfer process is crucial to enhance market development and to increase the use of Landsat data among the states. Presently, it is felt that the federal efforts to assist states to use Landsat data and to train them in the operational applications are too meager. States also voiced their concern about the credibility of private industry to provide user assistance. It was felt that presently the majority of states lack the technical expertise needed to evaluate the capabilities of private industry and effectively monitor a contracted effort. The state users identified the creation of regional user assistance programs, comprehensive training activities and widely distributed documentation concerning Landsat applications, available equipment, software and developed procedures as the key elements of the needed technology transfer effort.

It was pointed out by many users that an increased emphasis on technology transfer will result in a more knowledgeable community of users who, in turn, would have much greater probability of effectively demonstrating to state policy makers the value and benefits of incorporating Landsat into operational state programs. Without the development of a systematic technology transfer process, the intermediate step between research and development and operational use would still continue to be largely missing. From state users' perspective, the development of a systematic technology transfer effort would complete the full development cycle of the Landsat program and, in fact, make it a complete and more productive system. The requirement for technology transfer is emphasized in the following recommendations from the NCSL Final Report:

> "For an effective technology transfer process, NASA, in its research and development role, should establish an organization of an operational, as opposed to developmental, nature to carry out this process. The transfer of technology, in this case, also requires the organized cooperation of an array of various institutions".
>
> "Regional user assistance centers should be established. These centers are not to exclude the development of state data centers which could perform a coordinate role with the regional centers for a 'funneling' effect. "

3.4.3 Technical System Performance Characteristics

The presently proposed technical capabilities of Landsat-D are the results of a series of requirements evaluations by various user groups during the last several years including the recent study by the

Committee on Remote Sensing Program for Earth Resources Survey of the National Research Council. As a result, this evaluation did not address the technical performance requirements in terms of the overall user requirements. Instead, it was directed towards determining the incremental value of the specific improvements in Landsat-D over the existing Landsat I and II systems to state programs.

Numerous specific applications have been projected to uniquely benefit from the improved spectral and spatial capabilities of Landsat-D over Landsats I and II. These applications and referenced organizations are listed in Table 3-3.

An evaluation of the user needs of over forty state agencies in the five state area consisting of Illinois, Iowa, Minnesota, Missouri and Wisconsin was performed by Washington University to determine the additional specific data items that the improved Landsat-D is capable of providing over the present Landsats I and II in selected application areas. A total of 54 data items was identified in the 13 selected application areas which require the improved capabilities of Landsat-D. Table 3-4 on the following page identifies the data items and corresponding applications.

3.5 Benefits

Landsat data normally benefit user organizations in two ways: (a) as a source of totally new and incremental information which existing sources are incapable of providing, and/or (b) as a source of information which is a capable substitute for existing data sources resulting in a cost savings.

3.5.1 Incremental Capabilities (New Benefits)

The majority of organizations use Landsat because it enables them to "do new or additional" functions which otherwise would not be attempted with conventional techniques. It provides a new perspective and results in additional information which has a positive impact on the effectiveness of various organizations. Typically, the benefits resulting from the incremental capabilities of Landsat are not easily quantified. These capabilities and the associated benefits are described in the ensuing paragraphs. To provide a user's perspective of each Landsat capability, a user statement relating to the capability is also provided in selected cases.

(a) In many applications, the availability of Landsat data with reasonable costs to the user provides state resource managers with the only feasible means to accomplish a required resource inventory. Without Landsat, the cost, time and manpower involved in the use of conventional techniques would be too prohibitive to permit implementation.

TABLE 3-3

APPLICATIONS ENHANCED BY LANDSAT-D

- Increased accuracy in boundary delineation, land category identification and discrimination in broad land use determination - Southern Growth Policies Board - Letter II-B (1)

- Improved pinpointing development problems in settings where ownerships and land uses have a high degree of diversity - Tennessee Valley Authority - Letter II-B (3)

- Further breakdown of forest types by species rather than broad categories - Tennessee Valley Authority - Letter II-B (3)

- Extraction of nearly all Level II land use categories (NCSL Final Report-p. 43)

- Detection of smaller and narrower water bodies, as well as smaller areas of irrigated land (NCSL Final Report - p. 52)

- Improved urban applications - Atlanta Department of Budget and Planning - Letter II-D (1-1)

- Detection of thermal effluents and increased water quality analysis - Tennessee Valley Authority - Letter II-B (3)

- Improved geologic mapping, ground water hydrology and materials composition analysis - (NCSL Hearings on Landsat)

- Improved wetlands mapping (NCSL Final Report - p. 48)

- Increased water penetration capability in coastal zone management and inland water quality evaluation (NCSL Final Report - p. 49)

- Improved accuracy in the recurring need to monitor shoreline erosion (NCSL Final Report - p. 50)

- Improved route and site location in transportation facilities planning (NCSL Final Report - p. 50)

- Increased effectiveness of forest and crop disease detection, e.g., Southern Pine Beetle infestation (NCSL Final Report - p. 51)

- Improve strip mining and reclamation responses - NCSL Final Report p. 53; - Maryland Department of Natural Resources - Letter II-C (12-2)

- Improved evaluation of lake eutrophication condition through increased vegetative response and capability to penetrate water (NCSL Final Report - p. 54)

TABLE 3-4

PLAUSIBLE DATA ITEMS WHICH REQUIRE LANDSAT-D CAPABILITY IN AT LEAST ONE APPLICATION AREA

			APPLICATION AREA												
NUMBER	DATA ITEM	LANDSAT C RBV HELPS?	AGRICULTURE	CLIMATE AND WEATHER	ENVIRONMENT	FISHERIES	FORESTRY	GEOLOGY AND MINERAL RESOURCES	LAND USE - STATE	LAND USE - REGIONAL AND LOCAL	LAND RECLAMATION	PARKS AND RECREATION	TRANSPORTATION	WATER RESOURCES	WILDLIFE
3	AG. LAND PRODUCTIVITY STATUS		0												
4	AGRICULTURAL LAND USE		*						*	0			*		
6	AREAL WATER POLLUTION				0										
12	DAMAGE TO CROPS	YES	0	+					*	0					
15	FIELD CROP SPECIES		0						0	*					
17	FLOOD DAMAGE	YES												0	
18	FLOODING	YES								0					
19	FLOOD PLAIN LOCATION								*	0			+	*	
21	FLOOD PRONE AREAS								*	0			+		
22	FOREST CONVERSION AREAS						0								
26	FOREST STAND LOCATION						0		0	*					
28	FOREST STAND DENSITY	YES					0								
30	FORESTED LAND						*		*	0					
	GEOLOGIC FEATURES	YES						0	*	0			0		
	GEOLOGIC UNITS	YES						*		0					
34	GRASSLAND TYPE		0												
36	INDUSTRY LOCATION	YES					0		0	0					
37	IRRIGATED LAND		0						*						
39	LAKE TROPHIC LEVEL				*				0						
40	LAND COVER TYPE				*		0	*	0	+	*	+		*	
44	MINES AND QUARRIES	YES						*	*	0	0	0	+		
45	NATURAL AND SCENIC AREAS								0	+			+		
47	OIL SPILLS				0										
48	PIPELINE LOCATION									0					
49	POPULATION DENSITY	YES							0	+					
50	POTENTIAL LANDFILL SITES	YES			0										
51	POTENTIAL PARK SITES									0					
53	REFORESTED REGIONS						0								
55	ROCK TYPE							0		0					
56	RURAL WATER QUALITY				0										
61	SOIL TYPE						+	0	*	*		*	*		
63	STRATIGRAPHIC FEATURES	YES						0	*						
64	STRIP MINED LAND								+		0				
65	SURFACE DRAINAGE					*		*	*	+	+			0	
66	SURFACE WATER	YES				0			*	*	+		*	*	
67	TIMBER CUTTING	YES					0		*						
71	VEGETATIVE COVER TYPE					*	*		*	0	0	0	+	0	0
72	WATER IMPOUNDMENT VOLUME	YES								0				+	
76	WATER TURBIDITY													0	
	NUMBER OF DATA NEEDS FOR WHICH LANDSAT-D IS REQUIRED TOTAL = 54		5	0	4	1	7	4	7	15	3	2	1	4	1

KEY = 0 LANDSAT-D REQUIRED
* LANDSAT I OR II ADEQUATE
\+ SATELLITES INADEQUATE

"An inventory of four million acres of irrigated lands along the Snake River would be extremely useful to many organizations and agencies. Existing data is outdated and virtually unusable for current requirements. It would appear that the cost and time involved in a conventional survey would rule out a complete update. However, the staff of the Department of Water Resources believe that a survey based on Landsat data could be performed in a timely and cost effective manner. At least, those are the indications demonstrated through the project to date." (Governor Andrus, Idaho - Letter II - C (9-1))

(b) Because Landsat provides comprehensive coverage with relative economy, inherent flexibility, ease of use and availability, it often acts as a catalyst for states to develop comprehensive land inventory and management programs. It is extremely important that Landsat provides data coverage to work with in areas where none was previously available.

"The detailed, synoptic information produced has proven useful on a wide variety of land use and natural resources planning and management tasks. It would not have been possible for us to complete either of these inventories if Landsat data had not been available." (Commissioner Bucks, South Dakota State Planning Bureau - Letter II - C (17-12))

(c) The repetitive coverage frequency of Landsat is a new and powerful capability providing state users with a source of timely and current data which permits them to periodically and frequently monitor the changes occurring over time in a large geographical area.

"Because our region is a part of the St. Louis Metropolitan Area, our need for more frequent monitoring is increasing beyond the frequency that other federal agencies (i.e., U.S.G.S., U.S.D.A.) can provide. Therefore, without continuing the earth observations from Landsat we expect to incur increased costs with less efficient and timely data." (Mr. Theodore H. Mikesell, Executive Director, Southwestern Illinois Planning Commission - Letter II-D (8-11))

(d) In comparison to ground surveys and conventional aircraft coverage, Landsat data provide a basis for relative standardization over extensive geographic areas. The data provide more consistent and standardized information for a common time period and with a common set of technical parameters.

"I believe that perhaps the most important aspect of utilizing Landsat data is that information is obtained from a single source using the same criteria over the entire state

within a narrow span of time. This, as opposed to a myriad of sources working independently over long periods of time as in previous statewide inventories, has obvious advantages." (Mr. Robert W. Teater, Director, Ohio Department of Natural Resources - Letter II-C (15-3))

(e) The synoptic and repetitive Landsat data are uniquely suited to provide a frequent update of surface conditions and identify or pinpoint areas of rapid change or negative stress requiring additional analysis using more detailed survey techniques.

> "I believe that one excellent potential of these data is that changes in land use can be detected through updating of the information, various statistical information can be generated, and supplemental inputs can then be utilized for more detailed analysis of specific areas." (Mr. Robert W. Teater, Director, Ohio Department of Natural Resources - Letter II-C (15-3))

(f) The aggregation of new capabilities and information characteristics inherent in Landsat, e.g., its synoptic view and spectral manifestation of the environment, enable Landsat to extract new information which would have been impossible to acquire with conventional techniques or would have taken years to develop.

> "The Geological Survey of Alabama determined that a relationship existed between the location of the lineaments and the location of high yield springs and wells. This provided a link between the data acquired by satellite and the conventionally derived information on water yields. This type of application is extremely important to the overall development of the State. It is impossible to place a dollar figure on this type of use. It identified the occurrence of geologic conditions that we did not know about before the satellite and it would most likely have been years, if ever, before this condition was discovered." (Mr. Walter Stevenson, Alabama Development Office - Letter II-C (1-3))

(g) The grid (pixel) based digital form of Landsat data enables a high degree of compatibility with computer implemented processing and geobased information systems. This capability permits Landsat to be easily integrated and analyzed in concert with other data for comprehensive natural resources planning and land capability/suitability evaluation.

> "The Tennessee Valley Authority has made a commitment to implement an operational earth resources information system which will enable TVA to efficiently utilize spatial

data for regional planning, siting, and assessment activities during the 1980's. An integral part of this system will be information derived from Landsat data." (Mr. John S. Barron, Assistant to General Manager TVA - Letter II-B (3))

3.5.2 Substitution Capabilities (Cost Savings)

In addition to being a source of incremental information, state users identified Landsat data as a potential substitute for conventional techniques in applications where it provides a more economical and effective means. The estimates of cost savings involved in the use of Landsat as a substitute data source are presented in this section as results of the the following: (a) state Landsat expenditure and cost-effectiveness analyses; and (b) examples of cost-savings information presented as case profiles.

3.5.2.1 State Expenditure and Cost-Effectiveness Analysis (Point Sample)

A study was performed of the data collection activities and the use of Landsat data as part of these activities in three states. The objective of the study was to estimate: (a) the approximate dollar amount of the future state expenditures (FY 81) for Landsat data and related activities in a sample of states; and (b) the annual dollar benefit accrued to the states (beginning in FY 81) as a result of the increased efficiency/cost effectiveness associated with the use of Landsat data. The states of Georgia, South Dakota, and Texas were selected because they are a representative sample of the different levels in the progression toward adoption of Landsat by states as an operational and routine data source in their programs. The three states also represent diversity in geography, population, physical features, land use patterns and regional concerns, e.g., strip mining and coastal zone management. The results of the survey are presented in Table 3-5. The table shows the amount of funds expended on natural resources data collection activities and the funds spent on Landsat as one tool to accomplish some of this data collection in each of the three states. The funds expended on data collection and Landsat related activities in FY 76 was used as the baseline by the state resource managers to project their data collection expenditures for FY 81 (timeframe of launch of Landsat-D).

As shown in Table 3-5, the states projected that the FY 76 expenditure of $54,765,000 being spent for data collection in the three states would increase to $75,932,000 (increase of 39 percent over FY 76) and that the 1976 Landsat related expenditure of $436,000 would increase to $2,345,000 (increase of 438 percent over FY 76) by FY 81.

The users in the three sampled states also generally agreed that if they were to acquire the identical information with conventional techniques in the FY 81 time frame that they are presently planning to obtain with

TABLE 3-5

MARKET ANALYSIS
(SAMPLE SURVEY)

	FY 76 EXPENDITURES ($)		FY 81 PROJECTIONS ($)	
	DATA* COLLECTION	LANDSAT** RELATED	DATA COLLECTION	LANDSAT** RELATED
● GEORGIA	11,060,000	60,000	15,725,000	1,055,000
● S. DAKOTA	3,890,000	178,000	5,420,000	415,000
● TEXAS	39.815,000	198,000	54,787,000	875,000
TOTALS	$54,765,000	$436,000	$75,932,000	$2,345,000***

*NATURAL RESOURCES DATA COLLECTION EXPENDITURES

**INCLUDES EXPENDITURES FOR MANPOWER, DATA ACQUISITION, COMPUTER COSTS, TRAINING AND EQUIPMENT

***TOTAL LANDSAT RELATED MARKET FOR THE 3 STATES PROJECTED IN FY 81

Landsat, it would require a five fold increase in costs (over the cost of using Landsat), This would result in a 16 percent increase in the total estimated data collection costs for FY 81 or annual dollar benefit to the three states alone of about $9M. The $9M represents the approximate savings to the three states in efficiency resulting from the use of Landsat.

3.5.2.2 Cost Savings Case Profiles

Many users have compared the costs involved in using Landsat data with conventional techniques to accomplish their program functions. These comparisons are presented in the following case profiles as another indicator of the cost-effective use of Landsat:

Case 1: NCSL Final Report on State Use of Remote Sensing, p. 47.

To acquire land use/land cover data at Level 1 detail, the following cost comparison between the use of aircraft and Landsat data were obtained from 5 sources:

COST/SQUARE MILE

	A	B	C	D	E
Aircraft---	$3.59	$.48	$4.94	---	$4.88-$5.11
Landsat---	$1.52	$.13	$.79-.$.23	$.91	$.35-$.42

Case 2: Provided by Governor Straub, State of Washington, State Cochairman and Mr. Jack O. Padrick, Federal Cochairman, Pacific Northwest Regional Commission - Letter II-B (2).

"For example, the Washington State Department of Natural Resources is utilizing Landsat data for a Western Washington Forest Inventory (10 million acres). While this inventory could have been accomplished by standard methods within two years at an estimated cost of $2.0 million, the current estimates indicate that using Landsat data will allow a comparable inventory to be completed in one year at a cost of approximately $200,000."

"A recent survey to update available data on the location and extent of vacant lands in the City of Boise involved $70,000 using current methods. The same survey was accomplished using Landsat data in one man-month as compared to 15 man-years using current methods. Comparison of results from the two approaches was within 98% accuracy."

Case 3: Provided by Commissioner Dan R. Bucks, South Dakota State Planning Bureau - Letter II-C (17-2).

"As a point of reference, our Level 1 analysis, completed in less than 6 months, cost less than $5000, excluding only postage costs for the distribution of over 3,000 copies. Using the highest altitude aircraft available commercially and the smallest scale imagery obtainable, data acquisition costs alone would have been well over $200,000."

Case 4: Provided by Mr. James A. Duerk, Director, Ohio Department of Economic and Community Development - Letter - II-C (15-4).

"A 1965 land use inventory cost $191,000, or roughly $310,000 in 1975 dollars, and took two years to produce from data ranging seven years apart. The present inventory is expected to cost approximately $115,000 and take one year to prepare"

4.0 PRIVATE SECTOR

4.1 Landsat-D Industrial Users Perspective

The user sector that has progressed the most in terms of routine use of Landsat is the mineral and petroleum industry. However, the range of industrial users extends from individual entrepreneurs to major construction corporations. All have one thing in common: their ultimate commitment to Landsat will depend on its profitability.

a. Mineral and Petroleum

In order to fully understand the current and potential value of Landsat data, extensive discussions were held with major firms in this field. The following contacts were made:

On-Site Visits

- Burham Oil (Aminoil)
- Chevron
- Cities Services
- Continental Oil
- Exxon Research
- Gulf Research
- Halbouty Alaska Oil
- NL Industries
- Santa Fe International
- Superior Oil
- Trollinger Geo. Assoc.

Telephone Discussions

- Mobil
- Shell
- Texaco
- Geosat Committee

Contacts were made at highest possible management levels, but in all cases involved someone who had knowledge of the company's total use of satellite data and its relative value. Each company was apprised of NASA's concept of a Landsat-D mission. Each company was asked to submit, in whatever degree of detail it was willing to supply, a description of how the current Landsat system was being used, the limitations experienced, and the value derived. In addition, each was asked to submit the company's evaluation of all desired parameters for the Landsat-D program. To varying degrees, each contact did contribute position papers or verbal input.

The major use of current Landsat data in the petroleum and mineral industry is for reconnaissance mapping. Because of its synoptic view of earth, Landsat data is being used as the base onto which more detailed information is imposed. As a result, Landsat data is apparently making a positive contribution throughout the exploration process, and not just in general geological mapping where it represents a major tool.

Usage of Landsat data is industry-wide. This includes operational usage (best represented by Superior Oil, but also Gulf, Chevron, NL Industries, Halbouty, Trollinger, Santa Fe International, Mobil, and Shell), as well as research usage. Within the industry the distinction between operational and research is not always a clear one. For instance, in the case of Exxon, the Research Division processes all Landsat data including that used by the Operating units. Other companies making "research" usage of Landsat data include Continental, Aminoil, and Cities Services.

One strong point made by the users within the mineral and petroleum industry is the importance of a continuum of data over a period long enough to obtain global coverage under seasonal and climatic variations. The assertion that a single cloud-free scene of an area is sufficient to meet this industry's requirements is rapidly fading as the wealth of geological and geobotanical information contained in Landsat data is increasingly understood. This question is addressed in the technical documents provided as references. While the industry is currently building worldwide mosaics from the present Landsat data, the process would be repeated to obtain the new and additional data contained from Landsat-C and Landsat-D. As an example, Paul G. Harrison of Cities Service Oil Company (Letter III-J) states the following:

> "We know that multi-season coverage may offer more information than a single look by detection of such changes as vegetation cover, soil moisture and sun angle. Many clues of geological significance are transient in nature because of these factors, yet the previously cited costs for an airphoto survey make it unlikely that the clues will be sought after with this tool."

Although the industry is currently building worldwide mosaics from the present Landsat data, the process would be repeated to obtain the new and additional data contained from Landsat-C and Landsat-D.

The performance enhancements of the Thematic Mapper would definitely upgrade the value of Landsat data as an industry tool. However, for the realization of the full potential of satellite remote sensing data, this industry is requesting a program that has built within it the inherent flexibility that will permit modification of the Thematic Mapper to include a seventh band centered at 2.2 micrometers (Thermal IR) and a specialized stereo satellite (for three diminensional coverage) to be flown once every three-to-five years. The mineral and petroleum industry desires a program that has the flexibility to change based on the dictates of the experience and varying requirements of its users.

According to industry representatives, the application of data have already improved the nation's domestic mineral resources information base and will continue to do so on a much larger scale provided the entire program is continued and implemented with new stages of properly equipped satellites to produce vital new earth science data.

b. Forestry

The forestry industry as a whole is best characterized as being in the investigatory stage in its use of Landsat data. This includes the major forest products companies such as Weyerhaeuser, St. Regis Paper and International paper, as well as smaller ones. Weyerhaeuser has thus far established that the current Landsat is unable to meet two pressing operational needs: species identification within its holdings and monitoring of very young seedlings in reforestation projects. Investigation for application to other needs has been turned over to the Research and Development Department. A 60,000 acre area in North Carolina was recently classified into a number of categories at an accuracy of 90%.

St. Regis Paper is using Landsat data as input to their long range planning model for their information management system. The essential elements they look to from Landsat-D are:

- o A 8.5 million acre synoptic view of earth per scene
- o A continuous data source
- o 30-meter resolution (enabling one less level of underflight data)
- o 256 grey scale for enhanced classification capabilities.

Mr. Kenneth F. Bailey, Divisional General Manager, Southern Timberland Division, said "We feel such a system is mandatory if proper decisions are to be made as to the management of our natural resources in general, and forest resources in particular." (Letter III-A)

c. Construction

Bechtel utilizes Landsat data in such wide ranging construction projects as location of nuclear and fossil power plants, dams and hydroelectric projects, highway and pipeline routes, industrial complexes, airports, telecommunication projects, mining facilities and more. A document describing Bechtel Geology Group's use of Landsat data, its on-going requirements, and suggested improvements is included as Reference IV-C.

4.2 Current Applications of Landsat

Industry is the largest group purchasing Landsat data. An overview of the value of Landsat data to this industry is given by William V. Trollinger of Trollinger Geologic Associates - Letter III-I (2)): "Generally speaking, the Landsat imagery provides the overall synoptic view for regional geologic (primarily structural) interpretation which puts the detailed information into its regional context." However, the use of Landsat data is not limited to its structural information. The temporal aspect of Landsat data acquisition is also important. Paul G. Mathiew, Manager, Exploration Department, Gulf Research and Development says that (discussion with Mr. Mathiew): "Seasonal variations in moisture and snow cover have contributed to our interpretations."

Eugene L. Jones, Manager of Exploration Research at Mobil, says, (Letter III-E):

> "Our principal use of the data has been for regional geological studies, particularly tectonic analyses. These studies have been in support of Mobil's worldwide exploration for both petroleum and other mineral deposits.
>
> The applications have been fairly well balanced between North America and foreign areas, including Africa, the Middle East, and Far East.
>
> We have examined shallow-water offshore areas for geological features.
>
> In one instance, offshore Egypt, we did use Landsat imagery to determine shallow-water areas potentially hazardous to marine seismic surveys. In this case, bathymetric charts were pre-1930 vintage and of questionable reliability."

The scientific and technical reports documenting the use of Landsat data usage in mineral and petroleum exploration alone fills volumes. Two examples are: "a description of exploration in Guatamala" by Trollinger (Letter III-I (1)), and <u>Landsat Data Contributions to Hydrocarbon Exploration in Foreign Countries</u> by F. P. Bentz and S. I. Gutman (Letter III-F).

The general use of Landsat data throughout the industry is probably best summarized by Michel T. Halbouty in an article entitled, "Application of Landsat Imagery to Petroleum and Mineral Exploration," American Association of Petroleum Geologists Bulletin, Volume 50, No. 5, dated May 1976. The first six points of the abstract provide an excellent synopsis of Landsat's mineral and petroleum applications.

4.3 Need for Improved Capability

Because the mineral and petroleum industry is advanced in its use of current Landsat data, the need for the proposed improved capabilities of the Landsat-D mission are essential, but represent a minimum upgrade. To quote Chevron (Letter III-B):

> "We anticipate that Landsat 1, 2 and 3 will satisfy our needs for imagery acquired with the present MSS configuration. Once Chevron has obtained cloud-free coverage of the land areas, we will greatly curtail our ordering of MSS images. The proposed Landsat follow-on with improved spatial resolution and spectral bands will initiate a new cycle of image acquisition and interpretation.
>
> "Specifically, the new mid-IR (1.55 to 1.75μm) of the Thematic Mapper should greatly aid in recognizing hydrothermally altered rocks in the vicinity of potential mineral deposits. The improved spatial resolution will improve the ability to resolve specific targets while retaining the broad image coverage that has been so useful. The proposed thermal IR band (10.4 to 12.5μm) will provide sea ice monitoring capability during periods of arctic darkness. For geologic interpretation, our experience and that of other investigators indicates that thermal IR imagery must be acquired at night. Only experience will establish the applicability of this relatively low resolution thermal IR imager."
>
> Although not mentioned on the proposed Landsat Follow-on specifications, we believe that stereoscopic image coverage will be valuable. This is based on our work with the limited stereo sidelap from Landsat 1 and 2, that has minimal vertical exaggeration. We believe that complete stereo coverage of the earth's land areas with optimum vertical exaggeration would be valuable. Repeated coverage would not be necessary after cloud-free coverage of high quality images has been acquired."

In Energy Resources Exploration Petroleum (Bennett - Letter III-A), the industry position is summed up as,

> "It is unlikely that they (many companies) would acquire repeat coverage from future satellites unless there are significant improvements in spatial resolution and spectral coverage."

Most companies do acknowledge that the Landsat-D program, as presented to them, does offer sufficiently significant improvements to continue the benefits being derived, but NASA must not stop there. As Bennett, himself, points out,

> "Band 4 of Landsat 1 and 2 is currently used to map these (shallow seas) hazards; the water penetration band of Landsat Follow-on should be even more useful. If atmospheric scattering effects are not excessive, natural oil seeps may be detectable on imagery as aid to offshore exploration."

Gulf states,

> "The specifications for data acquisition outlined will definitely increase the usefulness of the data for geologic analysis. We would recommend in particular the inclusion of 2.2 micrometers in the spectral band coverage for its potential use in discrimination of rock alteration."

Jon W. Davidson of Superior Oil (Letter III-H) feels that,

> ". . . the present Landsat bands are not optimumly positioned for geologic mapping.
>
> In particular, we need bands centered at 1.6 and 2.2 micrometers. The 1.6 micrometer band is proposed for the thematic mapper on Landsat D; however, without the 2.2 micrometer band to utilize in ratioing, its value will be significantly diminished. Our experience indicates that ratioing of two bands in the same portion of the spectrum is much more useful in geologic mapping than single bands.
>
> The increased spatial resolution and dynamic range of Landsat D will certainly be welcomed by the geologic community; however, until the bands are placed in an optimum position for geologic mapping, the really large benefits of natural resource exploration from space cannot be obtained."

A more positive note appears in Exxon's statement (Letter III-C),

> "We consider Landsat one of the most important and significant projects undertaken by NASA. It has direct and immediate application in the search and development of our nation's natural resources. Implementation of proposed follow-on Landsat programs will significantly improve the system and allow even more direct application in the exploration for natural resources."

4.4 Benefits from Landsat

To quote Energy Resources Exploration Petroleum (Bennett - Letter III-A), it is,

> ". . . difficult, if not impossible to credit a discovery well (or mine) to a single technology. The time from beginning of exploration to drilling a well is commonly five years or more . . . On this time frame, the major petroleum (or mineral) benefits of Landsat are in the future."

However, the nature of those benefits is clear. For although the utilization of Landsat data has not resulted in the replacement of any geological or geophysical method, it has aided in the optimization and localization of the use of these methods which are considerably more costly than using Landsat data. This optimization is an increase in efficiency of mineral and petroleum exploration. The industry itself says that Landsat data is used for initial and general mapping, exploration concession selection, structural mapping, locating water resources, road mapping, pipeline routing and environmental monitoring.

Estimates of the 1975 expenditures for mineral and petroleum exploration worldwide using geophysical techniques only was \$51.4 million and \$1.19 billion respectively (Geophysics, Vol. 41, No. 4, p. 780, 1976). The total mineral and petroleum exploration expenditures in the U.S. alone for geological techniques has averaged about \$100 million annually over the past three years (this is an estimate based upon information from the joint survey by the American Petroleum Institute, the Independent Petroleum Association, and the Mid-Continent Oil and Gas Association published in The Oil and Gas Journal, p. 36, May 31, 1976, and from the Society of Exploration Geophysicists Annual Geophysical Activity Committee Reports published in past issues of Geophysics). The total geophysical and geological (G&G) expenditures for mineral and petroleum exploration for 1975 was, therefore, about \$1.34 billion. Of this amount, about \$920 million was attributed to airborne and land surveys which are directly effected by Landsat (\$420 million was expended on marine surveys which are not affected by Landsat).

The USGS estimated that an increased efficiency of 7% in its geological and geophysical operations would result from Landsat data (1969 National Academy of Sciences study of an Earth Resources Satellite Observation System). NL Industries found its increase to be in the range of 12-15%. More specifically, Dr. H. Leroy Scharon states, (Letter III-K):

> "the time element (for ore exploration) was reduced from a field reconnaissance of two years to several months. This alone represents a saving to NL of several hundreds of thousands of

dollars... In another case, which occurred in the United States, observing Landsat imagery over a known mineral district, we observed through the utilization of the infra-red bands, that one could interpret fracture patterns, not evident at the surface, in which ore occurs at 1,500-2,000 feet below the surface. Applying this technique over another area where a similar host rock at depth is known to exist, over an area extending some 200 miles east-west and 50 miles north-south, specific loci were spotted on exploration program initiated with a considerable decrease in time and dollars spent, and I might add with an exploration success. These are but two examples."

Using the USGS experience of 7% rather than the NL experience averaging 13.5%, assuming the 1975 Landsat effected G&G expenditures will not increase in the future, and assuming that all activities included in the $920 million 1975 exploration expenditure are directly effected by Landsat data, a conservative estimate of the value of Landsat to the mineral and petroleum industry is $69 million annually.

A few examples of cost benefit from Landsat in petroleum exploration are as follows:

In Energy Resources Exploration Petroleum Bennett states, (Letter III-A):

The savings in manpower and time could be appreciable (in geologic studies), especially in areas where base maps are poor or lacking..."Trafficability and access information from Landsat maps can save several days of crew time each month at a typical cost of $5,000 per day in isolated foreign areas."

Trollinger states, (Letter III-I):

"It is very difficult to quantify the amount of cost savings effected by utilizing Landsat data over a totally conventional program (aerial photography). This is because the type and quality of information derived is quite different. However, the following information is given for general comparative purposes:

For the Guatemala-Mexico area mentioned above, the cost breakdown roughly is as follows:

a. Detailed study using aircraft photography (approximately) 1,500 square miles-$6.50 per square mile = $9,750.00

b. Regional study using Landsat (approximately) 150,000 square miles-$ .20 per square mile = $30,000.000

c. $6.50 per square mile divided by .20 per square mile = 32.5

This means that unit costs for mapping using conventional photography were 32.5 times more costly than using Landsat. However, the products are totally different in quality and amount of detail and therefore, the cost figures are of limited value. The resultant Landsat photogeologic map was prepared at the scale of 1:1,000,000, whereas the conventional photogeologic map was prepared at the scale of 1:50,000. Thus, the conventional map is more comprehensive than the Landsat map—however, the Landsat map provides data that has been heretofore virtually unobtainable at any cost." (Note that over $20 million is spent annually on airborne exploration for petroleum).

Because it requires 4-5 years after a potential mineral or petroleum deposit is located to determine its potential value and to initiate extraction operations, and because the mineral and petroleum industries have only been using Landsat for a short period of time, it will require a few more years to identify point cases of actual benefit.

5.0 LANDSAT DATA ANALYSIS, SERVICE AND EQUIPMENT SUPPLIERS

5.1 Overview

Since the launch of Landsat-I, a growing industry has emerged to provide specialized data products, data analysis equipment and consultation services to end users of Landsat data. Business opportunities for these firms are increasing as more users gain interest and confidence in Landsat data for practical use. A large share of the economic benefits of earth resources satellites can be measured by assessing the vitality of this service industry.

5.2 Service Supplier Survey

In order to gain a totally independent perspective of the value of Landsat, a survey of nine companies involved in the commercial utilization of Landsat data was conducted to determine the size of the potential market for selected products and services. (No attempt was made here to evaluate the marketplace in total or the ultimate contribution to the GNP; i.e., the value of the end-products and/or services resulting from the use of Landsat data.) The market survey can give some indication of the monetary value users are willing to place on Landsat. In addition, it represents an assessment of Landsat by a segment of the public that has risked its own money on its beliefs. Significant amounts of investment capital have gone into product development (image processing equipment, computer software development, etc.), personnel training (both for analysis and marketing), and to market development itself (evaluation, forecasting, advertising, etc.).

The criteria for selecting the companies sampled were:

1. The company must be currently involved in providing or evaluating Landsat-based products and/or services.

2. Market forecasting must be part of the company's standard business procedure.

3. The company represents a major segment of the Landsat market (in terms of what it offers). The present or forecasted Landsat-based business represents a major portion of the firm's total business, or a large dollar volume is derived or projected from Landsat-based business.

With these criteria in mind, the following companies were requested, and agreed, to participate:

COMPANIES	INITIAL CONTACT	TITLE
Bendix Aerospace	George R. Macomber	Vice President
COMSAT	Dr. Joseph V. Charyk	President
DICOMED	Wayne R. Huelskoetter	Vice President
EARTHSAT	J. Robert Porter	President
ESL, Inc.	Dr. William J. Perry	President
General Electric	Daniel J. Fink	Vice President
IBM Corp.	F. G. (Buck) Rodgers	Director of Corp. Marketing
I^2S (Div. Stanford)	George G. Hoberg	Vice President
TRW	Dr. George Solomon	Vice President

5.3 Survey Results

The responses provided to NASA differed widely in approach and content. Specific projections could not be drawn directly from the data, but a number of important general conclusions were evident. First, the "market" is sizeable and diverse in terms of both products and services. The market should be at least $1 billion from 1976-1985 and could range up to $4 billion or beyond. This includes sales both domestically and abroad.

There was consensus among the eight respondents that a lack of commitment to further satellites would have an adverse impact on the market although the timing and magnitude of this is not clear. It was clear however, that a three year interruption in an on-going program, (e.g., a satellite failure with no backup), would seriously affect the market. All the responses indicated that, in event of a three year interruption, the market would decline by 70-90 percent. There would be slow, if any immediate recovery following the launch of another satellite.

5.4 Service and Equipment Supplier's Concerns

From the survey and private discussions with representatives of the industry, NASA gained some understanding of the concerns of the companies operating in this area. The realization of the market potential for Landsat-derived business is largely dependent on government policy decisions. A commitment to provide continuity of data is emphasized as a major step which will be needed to stimulate the market for Landsat products and services. A full commitment to continuously available data would require a new start in time to orbit the new satellite before, or coincidental with, the demise of the old and sufficient backup satellites, to replace satellites no longer functioning, or, during the shuttle era, being refurbished or modified. The extent to which the potential for discontinuity is known by users will determine

the effect on the market. Unless there is a commitment to continuity, many will not make the investment necessary to use Landsat data operationally if there is a lingering threat that the data will cease to be available.

A second governmental policy issue which will determine the market potential is the service supplier's access to the data—at what points and under what conditions? Direct readout of the data from Landsat would provide the opportunity for general and specialized distribution services which could perhaps be provided more quickly and cheaply than through central facilities. Private industry would, in order to enter the market, have to provide, at minimum, products which equal the government's in price and quality. This competition might result in better products at lower prices.

This is not to infer that private industry should replace the government in the entire distribution process. According to the industry, the archiving function does not represent a viable business opportunity. Yet, since the full worth of Landsat data is unknown and historical and seasonal comparisons are of demonstrated value, the archiving function is essential.

One of the participants in the suppliers study, COMSAT, has presented a concise view of the major business concerns in this area in the letter to Dr. Fletcher which is included in the reference section of this document. (Letter III-L)

Another major concern expressed by the service and equipment suppliers is government usurpation of possible commercial opportunities. True research projects are indeed worthy and necessary functions, and, where all can benefit from them, are well within the domain of the Federal Government. But, industry does not want NASA to undertake projects which could have been competed for and accomplished by the private sector.

6.0 FOREIGN USERS

While NASA has not formulated the Landsat D system characteristics on the basis of foreign needs, the Agency has experienced extensive and ever-growing foreign interest in existing and planned Landsat programs. At present, over 100 foreign countries are involved with the use of Landsat data, encompassing research through routine operational use. Seven countries have signed agreements with NASA to construct their own Landsat ground stations which involves expenditures of over $40 M for U.S. equipments. The three countries currently operating stations (Canada, Brazil and Italy) have this year begun to pay $200,000 per station per year for direct access to the satellites. The other committed stations will begin paying access fees six months after they become operational.

Many countries now realize the potential of Landsat in the planning of their economic development. Agriculture, being the basis of most of the economies of the emerging nations, requires a significant amount of information before meaningful plans can be developed. Whether the objective is increased yield, reduction of import dependency, or better utilization of soil and water, Landsat has proven to be a valuable tool in agricultural land capability evaluation and land use planning (see concerns of the World Land Use Survey Commission of the International Geographical Union relative to Landsat expressed in Letter IV-F). Many base mapping requirements can be accomplished readily and at large cost savings. Large scale planning for water sanitation projects and industrial/agricultural developments have found Landsat to be helpful. Landsat data, for example, was used by Taiwan to determine ocean current and sedimentation distribution in the planning and design of a major new harbor. In Thailand, Landsat identified the amount of forested area as 37% of land cover compared to 58% in the most recent conventionally performed survey (1961). This information is of economic interest since the mangrove forests are major cash crops. In Mexico, land use and land capability maps were prepared for large areas. Soil maps were prepared for the whole country. The Mexican investigators estimate reliability of the soil maps at 90% and the cost of preparation approximately 0.1¢/hectare mapped. The Inter-American Development Bank is currently training scientists to conduct a resource inventory of Central America using Landsat. In India, the World Bank is making land use maps of the State of Orissa which will be used for agricultural planning and water management. Landsat-D, with increased resolution and spectral sensitivity, will greatly reduce aerial and ground survey costs and time in preparation of these development plans.

Geological maps have been prepared in many countries and new faults and other geological features discovered. As a result, several countries claim to have located new deposits of minerals and petroleum. In Pakistan, potential copper deposits were identified using Landsat. In Chile, Landsat data has

identified areas of potential copper deposits. In Bolivia, lithium and potassium deposits were confirmed in areas identified by Landsat data. In Egypt, petroleum, water, uranium and a new vein of iron ore were discovered using Landsat (Letter IV-B).

In addition to geological maps, basic cartographic mapping has been enhanced with Landsat. For example, in Brazil's Amazon region, many rivers and towns were found to be in different locations than originally thought and new islands were discovered.

Many actual or potential economic benefits have been reported. For instance, in France, Electricite de France, the national electric company is using Landsat to plan development of certain estuaries and to help select sites for nuclear power plants. The latter application is also being practiced in Egypt. A new gas pipeline route selected in Bolivia using Landsat saved the government approximately $3 million. In Argentina, Landsat was used to map ground water depth and salinity saving several hundreds of dollars per square kilometer mapped. Table 6-1 presents a summary of selected cases where Landsat has resulted in economic benefits to various countries.

Countries such as Iran plan to use Landsat operationally and are investing millions of dollars to do so—most, if not all of which will be spent in the United States. Canada, of course, has already declared remote sensing technology from space to be a potential commercial world-wide market and is assisting industry to pursue various aspects of the market. Japan, France, and the United Kingdom are other countries which see the national and economic implications of Landsat technology. Should the U.S. relax its present leadership in this technology, it is apparent that foreign countries will capitalize on U.S. technology. The ability to accurately survey world-wide agricultural crop yield on a continuing basis is perhaps one of the greatest benefits which can result from Landsat technology. The societal benefits related to the world food problem are obvious and Landsat-D with its increased resolution can play an important role in the U.S. effort to attack the growing world food problem.

Landsat is also being used effectively by AID and international lending institutions (see World Bank letter from Wolfram Drews--Letter IV-E). Recently, the World Bank assisted India in developing a land use classification using Landsat data. Many other examples can be cited including the World Bank base mapping and forest inventory project in Indonesia, and the land use analysis in Bangladesh. AID is assisting many countries in learning how to use Landsat in their mapping and resources management. The recent AIDSAT demonstration of remote sensing technology to some 30 countries was undertaken by AID as a way of familiarizing developing country officials with the potential of this technology. In many of these areas, Landsat is the only potential source of current as well as comprehensive data concerning a nation's resources.

Many U.S. based multi-national engineering and construction companies depend upon Landsat routinely for construction planning and engineering geology (see Bechtel's Geology Group's statement, Reference IV-C). Data from the Thematic Mapper will greatly reduce ground and photographic surveys of topography, vegetation, soils, and impervious materials needed for transportation and construction.

The Landsat-D program is, therefore, important to other countries especially the emerging nations, U.S. foreign business, and U.S. technological leadership.

TABLE 6-1
ECONOMIC BENEFITS TO FOREIGN COUNTRIES
RESULTING FROM LANDSAT USE*

(1) Numerous Countries (Atlantic Ocean) - areas of high/low phytoplankton densities discovered resulting in benefit to fisheries industries.

(2) France - Electric Co. using Landsat to plan development of estuaries and select sites for nuclear power plants.

(3) Bangladesh - 4000 square miles of new land discovered.

(4) Japan - Pollution dispersion in Osaka Bay monitored.

(5) Thailand - Mangrove forest inventory.

(6) Vietnam - land capability analysis of Mekong Valley used for land development, refugee settlement.

(7) Egypt - iron ore discovered; Landsat being used to select sites for nuclear power plants.

(8) Saudi Arabia - desert locust breeding sites identified using information concerning vegetation patterns.

(9) South Africa - possible sources of water identified that could be tapped and used in periods of droughts.

(10) Argentina - ground water depth and salinity mapped at \$300-600 savings/KM^2

(11) Bolivia - gas pipeline route change resulted in \$3 million savings; Landsat also used to select highway routing.

(12) Chile - area of potential copper deposits discovered.

(13) Mexico - land use maps produced at significantly less cost; land use potential maps prepared for planning.

(14) Virgin Islands - hydrographic (depth) charts prepared at lower costs.

(15) Brazil - 200 square miles in Amazon discovered (previously unmapped).

(16) Pakistan - copper discovered.

(17) Bolivia - lithium and potassium deposits discovered.

*The references for these economic benefits are the Landsat Significant Results File and the NASA Earth Resources Survey Symposium Proceedings

7.0 MULTISECTOR USER EVALUATION

7.1 Applications Survey Groups

The results of the Applications Survey Groups (ASG's) were reported in detail in a five-volume document, available from NASA's User Affairs Division. The general concensus of the ASG's (see Table 7-1) for organizations involved was extremely favorable to the Landsat concept. Recognizing that Landsat data is one of many tools utilized in resources management and planning, the ASGs felt that Thematic Mapper data from Landsat-D will be of tremendous value to them. Overall, the Landsat-D characteristics most strongly desired by the Groups were:

- Resolution of 30 meters (Thematic Mapper)
- Increased spectral sensitivity (Thematic Mapper)
- Continuation of MSS data to assure compatibility with current Landsat information
- A two satellite system giving nine-day repetitive coverage

The ASG report was also of great value in that it did identify some specific dollar costs and benefits associated with the use of Landsat-D. These figures were incorporated into the economic analyses of Landsat-D conducted by NASA.

7.2 Battelle Survey

The Space Applications Board of the National Research Council requested NASA to undertake a general survey of users of earth resources data. This study was to identify current data users, examine their usage of Landsat and aircraft remote sensing data and determine improvements suggested by users to make the data more valuable. Battelle Columbus Laboratories was given responsibility to conduct the survey.

Battelle's basic approach was to develop a detailed questionnaire which was to be administered to a large number of users. Follow-up personal interviews were also planned. As the study was beginning, the Office of Management and Budget independently asked NASA to survey the user community at the impending Earth Resources Survey Symposium, to be held in Houston, Texas in June 1975. These efforts were then combined; the questionnaire was given first to the Symposium attendees and later to a larger group of general users. Battelle's final report, published in June, 1976, was distributed to NASA management and field centers, Congress, GAO and OMB. Several general trends were very clear from the study:

1. The community of Landsat data users is large and growing. The study identified hundreds of different organizations currently using remote sensing information and showed that data sales from the three federal data centers has increased dramatically since the launch of Landsat-I (Survey of Users of Earth Resources Remote Sensing Data, March 31, 1976 p. 17). Currently, private industry accounts for purchases of the largest amount of Landsat data (25%) and state and local government the smallest (1%, although much of the data purchased for use by state and local government is obtained by educational institutions or private service companies). Landsat data use is uniform among the various disciplines for the most part, although environmental monitoring applications of Landsat are lagging behind.

2. Landsat data utility varies among users. Some users are already making operational use of Landsat data, e.g., the petroleum and mineral exploration companies. Other users are still in the research stage, although they see great potential for Landsat use in their disciplines. The survey showed that agriculture, land use and water resources management will benefit the most from earth resources data in the future.

3. Future system improvements will increase the utility of Landsat data to users.

   While many users find the current MSS data from Landsats I and II very useful, a number of system improvements are desired.

   a. Spectral Resolution - Many users are satisfied with the existing spectral bands, but the more advanced users recommend narrower bands and extension into the thermal and near IR regions.

   b. Spatial Resolution - Most users recommended 10-40 meter resolution, especially those involved in land cover mapping and change detection. Many users are working extensively with 80 meter data, they are constrained to experimental uses and large area surveys.

   c. Repetitive Coverage - Although some users want more frequent coverage, 18 day coverage seems adequate. Some users expressed specialized coverage requirements for foreign areas or, in the case of geologists, stereo coverage.

d. Data Reproduction and Distribution - User dissatisfaction with data delivery times was very clear from the survey. Also there was significant demand for a quick look capability.

The overall results of the Battelle study generally support other findings on the same subject. The report is a good general compendium of the current state of Landsat data usage.

TABLE 7

USER ORGANIZATIONS REPRESENTED IN APPLICATIONS SURVEY GROUPS

FEDERAL	STATE/REGIONAL	UNIVERSITY	INDUSTRIAL
USGS/GAP, WRD, LUDA, TOPO., GEOL. DIV., EROS	DEPT. OF WATER RES. (SACRAMENTO, CA) (DENVER, CO)	TEXAS A&M	ST. REGIS PAPER COMPANY
		UNIVERSITY OF CONNECTICUT	EXXON
NSF	AREA IV REG. PLAN. (OTTUMA, IA)	UNIVERSITY OF CALIFORNIA	FMC
OERC		UNIVERSITY OF VIRGINIA	MONSANTO COMPANY
EPA EMSL/MOW	NAT. WEATHER SERV. (SACRAMENTO, CA)	UNIVERSITY OF CALIFORNIA AT SANTA BARBARA	GEOSCIENCE, INC.
NOAA/OCEAN SURVEY,	GT. LAKE BASIN COMM. (ANN ARBOR, MI)	CALIFORNIA INSTITUTE OF TECHN./JET PROPULSION LAB.	HALBOUTY ALASKA OIL
NPS/NSTL	WATER DIV. BOARD (AUSTIN, TX)	BUREAU OF ECON GEO.	BITTINGER AND ASSOCIATES
USAC OF ENG./WATER RESOURCES, NCD	DEPT. OF CONSERV. (SACRAMENTO, CA)	COLORADO STATE UNIVERSITY	RALSTON PURINA
OCE	(NASHVILLE, TN)	CORNELL UNIVERSITY	CALIFORNIA EARTH SCIENCES
ETL	STATE ED. DEPT. (ALBANY, NY)	UNIVERSITY OF CALIFORNIA AT BERKELEY	CARGILL GRAIN
EMA HYDRO. CTR.	DEPT. CITY PLANNING (LOS ANGELES, CA)	UNIVERSITY OF DELAWARE	ANDERSON CLAYTON
BUREAU/MINES, CENSUS LAND MGMT. INDIAN	GEO. SURVEY (IOWA CITY, IA)	STANFORD UNIVERSITY	CHEVRON OIL FIELD
		SAN DIEGO STATE UNIVERSITY	METRICS, INC.

TABLE 7

USER ORGANIZATIONS REPRESENTED IN APPLICATIONS SURVEY GROUPS

FEDERAL	STATE/REGIONAL	UNIVERSITY	INDUSTRIAL
ERL	DEPT. OF NAT. RES. (ATLANTA, GA)	UNIVERSITY OF MARYLAND	TROLLINGER GEOLOGICAL ASSN.
USDI/FISH AND WILDLIFE SERVICE	KERN CTY. WATER AGENCY (BAKERSFIELD, CA)	AUBURN UNIVERSITY	GEOSPECTRA CORPORATION
USDA/ARS/FOREST SERV.	STATE PLANNING AGENCY (ST. PAUL, MN)	UNIVERSITY OF GEORGIA	UPLAND INDUSTRIES
HUD/FIA	REG. COUNCIL OF GOVTS. (DENVER, CO)	UNIVERSITY OF WISCONSIN	
DEPT. OF TRANS.	RES. INFORMATION SYS. (PHOENIX, AZ)	UNIVERSITY OF WYOMING	
		PENNSYLVANIA STATE UNIV.	

REFERENCE SECTION ON LANDSAT USERS

TABLE OF CONTENTS

REFERENCE SECTION ON LANDSAT USERS

APPENDIX I

FEDERAL USER REFERENCES

TABLE OF CONTENTS*

*NOTE: This appendix does not include material from the Interagency Decision Team (IDT) of the IDT Working Group, which has been documented in minutes of those meetings. However, the IDT material should be considered as the most significant and representative statement by the federal agencies concerning Landsat-D.

AGRICULTURAL RESEARCH SERVICE
WASHINGTON, D.C. 20250

UNITED STATES DEPARTMENT OF AGRICULTURE

OFFICE OF ADMINISTRATOR

AUG 24 1976

Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration
Washington, D.C. 20546

Dear Dr. Fletcher:

I am pleased to respond to the request concerning ARS's particular LANDSAT experience and our general interests in natural resource information gathered by orbiting spacecraft.

A National Remote Sensing Workshop was held within ARS in March of this year. It was determined that satellite digital and image products could be used to:

1. Determine kinds and acreages of crops
2. Detect nutrient deficiencies
3. Inventory rangeland (kind and condition)
4. Map soils and water bodies
5. Determine soil salinity
6. Estimate biomass/yield/vigor of crops
7. Map surface temperatures and areas of freeze-damaged crops
8. Determine watershed runoff curve coefficients

Each of these applications had been accomplished experimentally in one or more cases.

Other uses of orbiting spacecraft data that our scientists believe could be accomplished--but which cannot presently be accomplished because of insufficient resolution, lack of thermal band, or lack of funds to support an effort--include:

9. Detect disease, insect, and nematode damage to crops
10. Determine energy budgets for crops and land areas
11. Assess sedimentation, soil erosion, air pollution damage to plants and other aspects of environmental pollution and deterioration.

Our scientists and administrators are sincerely interested in remote sensing as a tool to document present natural resource conditions, to quantize dynamic processes, to develop and test models, to produce integrated application systems, and to provide farmers and ranchers with timely management decision facts. In-house funding for these studies had been stagnant for a number of years, but items in the FY 77 budget will more than double the in-house support devoted to remote sensing. We are hopeful that this effort can be further expanded in future budget deliberations.

An important prerequisite for increased effort of this agency is the assurance that satellite data be available on a continuing basis over the coming years. This would include supplementing existing data sources with more timely, complete, or accurate information on the one extreme, to development of completely new analysis and dissemination systems on the other. One obstacle we have faced is in establishing teams across geographical, disciplinary, and agency boundaries--especially teams in such diverse fields as photogrammetry, computer science, crop modeling, meteorology, physiology, soil science, and ecology. However, we are working on this. Experience and learning will occur simultaneously in extracting more of the information content from the satellite data and in developing necessary institutional innovations for analyzing and acting on it. Both processes will require time, so that the benefits to agriculture will likely grow geometrically with time in the coming years.

We anticipate cost effectiveness will be best achieved by making multiple uses of spectral data for a given geographic area. For example, a data set for a given LANDSAT scene could be analyzed for the information it contains about such diverse subjects as stored surface water; crop yield forecasting; land use as it affects water runoff, soil erosion by wind, and tax values; range condition and animal carrying capacity, and soil moisture conditions and evapotranspiration. Thus, we will be busy developing multiple use analyses and striving for elegantly simple systems that are based on sound scientific principles coupled with trained insight to dynamic biological systems. Cost effectiveness will be aided by determining the minimum amount of ground truth needed for acceptably accurate conclusions in any application.

The LANDSAT data provide a valuable resource for following changing land use patterns; for opportunely assessing synoptic catastrophic events such as droughts and floods, and more restricted events such as fire burns and hail damage; for calibrating ground conditions spectrally among growing seasons over large areas; and for selecting sites for experiments that are truly representative of the physiographic areas served. None of these considerations is easy to price, but utilization of just such information can make our research dollars go further and make our program more relevant to real world needs. In addition, the stimulating interactions our scientists have had with aerospace company representatives, NASA personnel, meteorologists, and scientists from other locations and countries cannot be priced.

Our scientists are eagerly awaiting the thermal band of LANDSAT-C and the LANDSAT follow-on missions. Of particular interest are the additional applications dealing with freezes, crop water stress, planting advisories based on observed soil temperature, plant cover and vigor as revealed by the thermal response, and synoptic energy budget and evapotranspiration

analyses. For example, we anticipate that data from the thermal band used in conjunction with the other bands will make the identity of cropped versus noncropped fields of wheat and other crops possible earlier in the growing season than did LANDSAT-1 and -2 data.

I believe you can see from the above discussion that ARS is interested in capitalizing on applications of LANDSAT follow-on data to agriculture in our areas of need, mission, and expertise. Ultimately, the information is to be provided to farmers and ranchers for current management decisions. However, it will be made available, also, to the Soil Conservation Service, the State Experiment Stations, and the many local agencies with whom we interact.

Sincerely,

T. W. Edminster
Administrator

cc:
R. L. Schweikart, NASA
S. C. Freden, NASA

United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

ADDRESS ONLY THE DIRECTOR, FISH AND WILDLIFE SERVICE

I-C

In Reply Refer To:
FWS/OBS

MAY 20 1976

Dr. James Fletcher, Administrator
National Aeronautics and Space Administration
Code A, Federal Office Building 6
400 Maryland Avenue, S.W.
Washington, D.C. 20546

Dear Dr. Fletcher:

The purpose of this letter is to offer a brief view of the potential of the Landsat Follow-on Program to supply critical information needs of the Fish and Wildlife Service. As you are probably aware, the greatest single threat to fish and wildlife resources is habitat loss; yet, to date, no satisfactory mechanism exists to adequately classify, inventory, and monitor such habitat. In order to address this problem we have recently established a long-term project to achieve a habitat assessment capability. We see Landsat as a continuing data source of this activity; if the potential of the Landsat Follow-on is realized it will become central to the Habitat Assessment Project.

Specifically, we are interested in the prospects of increased spectral, spatial and radiometric resolution offered by the proposed Thematic Mapper. In particular, the ability to thematically extract both wetlands and other vegetative units reliably to one acre or less (assuming an IFOV of 30 meters) will allow near-total reliance on Landsat for periodic update of the National Wetlands Inventory as well as the geo-base information system to be created as part of the Habitat Assessment Project.

We are just now beginning to use Landsat 1 and 2 data for regional analysis of fish and wildlife impacts of water resource development activities. The principal limitation on use of present Landsat data for more detailed studies is spatial resolution. Thus we see the Landsat follow-on as providing a more cost effective method of operation for these site specific, highly detailed assessments.

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I hope this letter has been of value in your consideration of the Landsat Follow-on Program. Please feel free to contact me or have members of your staff contact Dr. Allan Marmelstein, the Service's Remote Sensing Coordinator, if more information would be useful.

Sincerely yours,

Lynn A. Greenwalt

Director

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MAPPING AGENCY

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WASHINGTON, D.C. 20305

15 MAR 1976

ST

Mr. Charles W. Mathews
Associate Administrator for Applications
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Mr. Mathews:

On 13 January, representatives from the Defense Mapping Agency (DMA) had the opportunity to attend a meeting hosted by NASA Headquarters at which the results of the joint NASA-Cousteau experiment were briefed. The meeting revealed an impressive degree of success in determining water depths in shallow areas by the use of LANDSAT data taken in the high gain setting.

After lunch on the same day an informal meeting convened to discuss the band selections for the thematic mapper planned for LANDSAT-D. I wish to reiterate the DMA position as stated at this and previous meetings.

In the near future we at DMA intend to test the techniques demonstrated by the Cousteau experiment. If successful, we count on LANDSAT data as a potential source material in a high priority survey project this spring in the areas surrounding the Bahama Islands and the Virgin Islands. Looking toward the future, we urge the retention of the high gain mode capability presently available in LANDSAT-1 and -2, and we naturally desire one band of the thematic mapper optimized for water penetration. In selecting the center of this band, as well as its width, please be guided by the potential use which hydrographers see for its data. We expect to use LANDSAT tapes for shoal definition in relatively clear water areas. In the typically more turbid coastal confluence zone our surveys are of necessity taken at a larger scale, requiring on scene boat or ship assets.

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Control Number E-129
Due Date 3/29
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Signature of E

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

While we at DMA recognize that "LANDSAT" cannot be considered a misnomer, I trust that your configuration of LANDSAT-D will allow us to continue to enjoy the serendipity that has fallen to coastal hydrographers.

FOR THE DIRECTOR:

Owen Williams

OWEN W. WILLIAMS
Acting Deputy Director
Systems and Techniques

cc:
Mr. R. Schweikart,
NASA HQ (Code EK)

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

REPLY TO
ATTENTION OF:

26 MAR 1976

DAEN-CWM

Mr. Charles W. Mathews
NASA Headquarters
Code E
Washington, D.C. 20546

Dear Mr. Mathews:

We have reviewed the preliminary project plan for the Applications Systems Verification Test (ASVT) entitled, "Water Management and Control Project". If successful, we anticipate significant benefits in our water management and control activities. The Corps has completed some preliminary work on this test and has identified $150,000 to support Corps program costs for FY 1977. We will be prepared to commit an additional $250,000 in FY 1978 for implementation and training if the test indicates an effective application.

Sincerely,

Kenneth E. McIntyre

KENNETH E. McINTYRE
Brigadier General, USA
Deputy Director of Civil Works

CF:
Dr. Solomonson, Goddard Space Flight Cntr

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APPENDIX II

STATE, REGIONAL AND LOCAL

USER REFERENCES

TABLE OF CONTENTS

(1) NATIONAL
GOVERNORS
CONFERENCE (NGC)

National Governors' Conference
1150 Seventeenth Street NW Suite 600
Washington, D.C. 20036
(202)785-5600

August 16, 1976

Dr. James C. Fletcher
Administrator
National Aeronautics and Space
Administration
Washington, D. C. 20546

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Dear Dr. Fletcher:

Enclosed for your information is a copy of a policy statement which was adopted at the July, 1976, National Governors' Conference regarding the Landsat Follow-on Program. I believe you will agree that the Governors are becoming increasingly aware of the valuable contributions already made by remote sensing technology as applied to the management of natural resources. The Governors are most supportive of expanded applications of ERTS/Landsat data and appreciate the need for continuing and close cooperation between NASA and the States.

Sincerely,

David W. Johnson
Staff Director for the Committee
on Natural Resources and
Environmental Management

Enclosure

Action Copy to E
Info Copy to A, AD, AA, ADA, AC, B
A27490
Rec'd in NASA 8/20/76
Suspense Date 9/3/76
Prepare Reply for Signature of A

Action Copy to EK
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Rec'd in Code E 8/25
Control Number E-532
Suspense Date 9/1
Prepare Reply for Signature of A

National Governors' Conference
1150 Seventeenth Street N W. Suite 600
Washington, D C 20036
(202)785-5600

LANDSAT FOLLOW-ON PROGRAM

The Governors are becoming increasingly aware of the significance and importance of their timely natural resources management decisions. These decisions are becoming increasingly complex and difficult due to such factors as growing competitive demand for resources, dwindling availability of key resources, increased rate of resource utilization, the expanding regional nature of decisions as well as resulting impacts, and the necessity to achieve the desired balance between economic well-being and environmental quality.

State, regional and local resource managers are increasingly looking to remote sensing techniques, and in particular the Landsat program, as an important new technology that can make a significant contribution to the information base required for improved resources management. The improved and timely resource decisions resulting from the availability of Landsat-generated data have immeasurable benefits. These benefits include improved resource management, maintenance of environmental quality, and the reduction of funds and resources wasted as a result of delay and litigation associated with unresolved land management issues.

The Governors, therefore, resolve to support the Landsat follow-on program and would welcome imagery of greater resolution in order to assure continued and improved data for use in natural resources decisions by the States.

A (2) NATIONAL
CONFERENCE OF
STATE
LEGISLATORS (NCSL)

National Conference of State Legislatures

Headquarters Office
(303) 623-6600

1405 Curtis Street
23rd Floor
Denver, Colorado
80202

President
Tom Jensen
House Minority Leader
Tennessee

Executive Director
Earl S. Mackey

September 13, 1976

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Control Number E-896
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Signature of E

Dr. James C. Fletcher, Administrator
Code A
NASA Headquarters
Washington, D.C. 20540

Dear Dr. Fletcher:

I am pleased to inform you that, at their Annual Meeting in Kansas City, on September 3, the members of the National Conference of State Legislatures approved a motion in support of a resolution urging Congress to "assure the continuance of the satellite-based natural resources information collection by approval of the Landsat Follow-On Program." The resolution, as enclosed, does not appear in our Final Report because the meeting occurred after the printing of our Report.

For your own interest, the recommendations set forth in the Final Report of NCSL's Task Force on Uses of Satellite Remote Sensing for State Policy Formulation are as follows:

--Congress should make a firm commitment to insure the operational status of the satellite-based program;

--the states should take the responsibility of providing some form of support for this system;

--for an effective technology transfer process, NASA, in its research and development role, should establish or employ an agency or firm of an operational nature to carry out this process;

--both the private sector and universities should be encouraged to attempt development of effective, inexpensive data products for state use,

--regional user assistance centers should be established; and

--it is important to inform and update state legislatures regarding the potentials and limitations of this technology system for their states.

The completed Task Force Final Report is being forwarded to your office through formal contract procedures.

Thank you for your time and attention.

Sincerely,

Sally M. Bay

Sally M. Bay
Project Director

SMB:pw
Enclosures

cc: Donald Goedecke
Acting Director of User Affairs

J. Hugh Nichols
Task Force Chairman

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A-28622 ADA,
AC, B
Rec'd in NASA 9-12-76

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WHEREAS, the National Conference of State Legislatures' Task Force on Satellite Remote Sensing for State Policy Formulation has conducted a six-month, intensive review of State uses and tential uses of remotely sensed information; and

WHEREAS, the Task Force has found innumerable State activities about which more informed decisions could be made with the systematic availability of remotely sensed information; and

WHEREAS, these activities have included agriculture, forestry, natural resources conservation and development, minerals extraction and reclamation, energy conservation, air and water pollution detection and many others; and

WHEREAS, much recent Federal legislation, such as the Coastal Zone Management Act of 1972, has levied substantive requirements upon the States that can best be fulfilled by new and expanded information; and

WHEREAS, the National Aeronautics and Space Administration's Landsat Program has provided data on a developmental basis that has contributed to the States' ability to meet their expanded responsibilitites under many Federal programs, and

WHEREAS, the National Aeronautics and Space Administration has proposed a Landsat Follow-On Program to operationalize the data collection process of the Landsat Satellites; and

WHEREAS, this proposed Landsat Follow-On Program will pro- de for improved data collection capabilities as well as assure continuance of the current process; and

WHEREAS, the National Conference of State Legislatures' Task Force on Satellite Remote Sensing has found numerous State agencies successfully using this new tool experimentally but reluctant to make long-term commitments because of the uncertainty of the future operational availability of data; and

WHEREAS, the National Conference of State Legislatures' Task Force on Satellite Remote Sensing has unanimously approved a motion urging Congressional support for approval of the Landsat Follow-On Program as well as urging active State support of that Program; therefore

LET IT HEREBY BE RESOLVED, that the National Conference of State Legislatures urges Congress to assure the continuance of the satellite-based natural resources information collection by approval of the Landsat Follow-On Program.

Sponsored by Delegate J. Hugh Nichols, Maryland (for the Task Force)
Co-Sponsored by Senator James A. Mack, Arizona and Robert Testa, California.

B. MULTISTATE ORGANIZATIONS

GROWTH POLICIES
BOARD (SGPB)

SOUTHERN GROWTH POLICIES BOARD

Box 12293 Research Triangle Park North Carolina 27709 (919) 549-8167

22 June 1976

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AA, ADA
A 26631
Rec'd in NASA 6-29-76
Suspense Date NONE
Prepare Reply for
Signature of

Dr. James Fletcher, Administrator
National Aeronautics and Space
Administration
Washington, D.C. 20546

Dear Dr. Fletcher:

At the quarterly meeting of the Executive Committee of the Southern Growth Policies Board held in Tallahassee, Florida on June 11, a resolution was passed unanimously supporting the continuation and improvement of NASA'a Landsat Follow-On Program. I am enclosing a copy of this resolution as directed by the SGPB Executive Committee.

Our experience in dealing with our member Southern states in developing policies for the management of the South's land and natural resources has given the Southern Growth Policies Board an opportunity to observe the benefits of the Landsat program to state and local government. Enclosed is a state-by-state summary of how Landsat data is being used to support efforts to manage land and natural resources in the South.

We believe that the utility of Landsat data and the benefits expected to be accrued as a result of its use are based on the following capabilities and characteristics of Landsat generated information:

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(1) In numerous geographic regions the availability of Landsat data with reasonable costs provides the planners and resource managers with the only existing coverage and enables them to obtain an initial analysis of the land use activities and land capability of the area. Without the availability of Landsat data, the cost of conventional data would often be too prohibitive to permit data coverage and analysis of such areas.

(2) In selected applications, Landsat provides a more economical and effective means to accomplish resource planning and mangement functions which are presently performed by conventional aerial and ground surveys.

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(3) Landsat provides planners and resource managers with a direct source of timely and current data which enables them to monitor the changes occurring in a large land area in a frequent and systematic manner. The frequency of repetitive data is a new and powerful capability which improves the ability of planners to monitor the dynamic nature of certain natural resources and better appreciate, compare, and coordinate the planning activities of regional and local jurisdictions.

(4) Due to the inclusion of fewer system variables, the Landsat generated product is more uniform and standardized in all aspects and often more accurate over extensive geographic areas. The high level of aggregation of Landsat data is also significant in that it provides a uniform product to be utilized at higher and broader jurisdictional levels without necessitating the expense and time required to aggregate detailed data often generated with systems having varying technical parameters.

(5) As a result of its synoptic coverage, Landsat provides a superior and more economical discrimination mechanism with which to identify and delimit areas which are critical or in the process of change, and require additional analyses using more detailed survey techniques.

(6) The compatibility of Landsat data with computer-implemented processing and classification techniques and geo-based information systems enables Landsat data to be easily integrated and analyzed in concert with other data. The implications of the compatibility of Landsat with computer processes are extremely positive and include reduced processing time, timeliness, increased objectivity, extraction of increasing information detail, flexibility of scale and format, compatibility with information systems and computer modeling, and a capability to aggregate data at varying levels.

(7) Due to inherent characteristics of Landsat data such as its synoptic view or its spectral perspective; it is capable of extracting new information about the environment which is not capable of being acquired by conventional techniques.

Based on the experience of its member states with the present Landsat, the SGPB firmly believes that it is in the interest of the South, as well as the Nation, that NASA be provided with the appropriate resources to build upon the very substantial progress which it has made in recent years toward the development of an operational earth resources survey satellite capability. The increased spectral sensitivity, spatial resolution and the improved data distribution system will enable the using organizations to extract increasingly detailed information about a greater number of resources and receive the information in a timely manner. In addition, a commitment to data continuity represented by the Landsat follow-on program would encourage resource managers and user agencies in the member states of the SGPB to have confidence in the duration of the Landsat program and result in an increased conversion to and use of Landsat data to meet their legislative and programmatic needs.

Sincerely,

William L. Bowden

William L. Bowden
Executive Director

WLB/bz

Enclosure

SOUTHERN GROWTH POLICIES BOARD

Box 12293 Research Triangle Park North Carolina 27709 (919) 549-8167

RESOLUTION
IN SUPPORT OF
THE LANDSAT FOLLOW-ON PROGRAM

WHEREAS, the demand for and utilization of natural resources is constantly increasing due to an increased population and an increased rate of consumption per individual, and

WHEREAS, the supply and quality of natural resources are finite, and

WHEREAS, the region and the states represented by the SGPB are experiencing significant and rapid population growth and development, and

WHEREAS, the SGPB has taken a strong interest in the proper management of the South's natural resources and has identified specific recommendations directed toward optimizing the regional growth and achieving the desired balance between economic development and environmental quality, and

WHEREAS, there is a keen awareness by the SGPB of the significance, increasing complexity and lasting impact of decisions which are made relative to the use of natural resources in the South, and

WHEREAS, the SGPB recognizes that an essential requirement for improved decision-making and intelligent resource management is an effective information base, and

WHEREAS, the SGPB strongly believes, on the basis of previous experience, that the type of information obtained by remote sensing technology from the Landsat program is extremely useful to the Southern states in providing the information necessary for the analyses of their natural resources, and

WHEREAS, the SGPB member states have indicated a strong interest and intention to use Landsat data to assist their resource management programs in the future and has approved a resolution supporting the expansion of the technolgy transfer capacity at NASA's Earth Resources Laboratory in Slidell, Louisiana.

THEREFORE, the Executive Committee of the SGPB hereby strongly endorses the continuation and improvement of the NASA Landsat system through the implementation of the Landsat follow-on program and associated user assistance and technology transfer efforts as a key step in the provision of improved and cost effective remotely sensed information required by the states to effectively manage their natural resources.

The resolution by the SGPB in support of the Landsat follow-on program is based on the knowledge and experience of state, regional and local resource managers in the application of Landsat data to earth resource programs in the South. The applications of present Landsat data have proven extremely useful and provide a basis upon which to expect significant socio-economic benefits to be accrued to the states of the South as a result of the continued availability of Landsat data.

William L. Bowden

William L. Bowden
Executive Director and Secretary
Southern Growth Policies Board

This resolution was adopted by action of the Executive Committee on June 10, 1976. As part of the action it was determined that the resolution should be fowarded to Dr. James C. Fletcher, NASA Administrator, and to Mr. Herb Wiltsee, Southern Governors Conference, for their consideration.

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DOCUMENT OF SUPPORT

FOR THE LANDSAT FOLLOW-ON

RESOLUTION

6/22/76

DOCUMENT OF SUPPORT FOR THE LANDSAT FOLLOW-ON RESOLUTION

Most of the member states of SGPB are experiencing an accelerated rate of growth in population and the development of associated service and industrial facilities. As a result, the South has been extremely active in the application of Landsat data directed to developing an effective information base upon which intelligent resource management can be performed in preparation for the regional growth. The applications of Landsat by the states have been diversified and include agriculture, coastal zone management, forestry and vegetation, land use planning, land suitability evaluation, soil and geology, water resources management and environmental monitoring. To provide a synopsis of these activities, this document will describe some selected applications which are being made of Landsat by a variety of states and will present a Landsat activity profile of a sample of states.

Several states in the South have developed or are in the process of developing Landsat geo-based resource information systems which integrate and combine Landsat data with other conventional types of data such as economic, demographic and other natural resources information. This type of computerized information system is capable of aggregating, prioritizing, and analyzing the necessary attributes of an area of interest for the purpose of land suitability analysis and land use planning. The capability of Landsat to provide timely updates of land cover changes to a resource information system is a powerful tool in maintaining a current information base upon which to make land planning decisions.

The states of Mississippi, Georgia, Texas and Alabama are presently developing the Landsat based information system capability. Mississippi is completing the development of its Natural Resources Inventory and Information System which is based on a forty acre cell and designed to provide improved information for timber inventory and management, water quality monitoring, wildlife habitat mapping and a variety of other uses. The system concepts and elements are specificially designed for the state, regional and local users. They consist of the use of simplified pattern recognition software suitable for use by a general purpose digital computer, low-cost image displays, integrated use of satellite and aircraft data, and a capability to correlate and analyze Landsat data with conventional information. Georgia has decided to utilize much of the technology generated as a part of the Mississippi system and apply it in the development of its own integrated natural

resources information system using Landsat generated data. Texas is utilizing computer-implemented techniques initially developed for wildlife habitat mapping to develop a specialized Landsat based information system for use in the Coastal Zone Management program which will be ultimately integrated into the existing Texas Natural Resources Information System. Alabama is also developing a Landsat based land system which will utilize a multisource base of Landsat data aerial photography and ground truth data. The system will be directed toward landscape change detection, monitoring resource development, monitoring forest and agricultural practices, and monitoring environmental impacts.

Landsat data has been used by a number of state geological surveys for terrain evaluation and as an update to their knowledge of geological structures in their state or region. The geological uses of Landsat data in the South have been successfully utilized for two basic purposes: (a) construction, revision or edit of geologic maps, and (b) significant input to mineral and petroleum exploration strategies. The update of geologic maps and and the associated increase in the knowledge of regional geology has significant applications in hazard assessments, and overall land suitability analysis. As an example, Landsat data was used as a significant contribution to a regional site selection planning survey of the Delmarva Peninsula concerned with determining the most compatible location for the possible siting of ten nuclear power plants in the future. The siting of the plants was evaluated on the basis of selected criteria or earth resources information. Landsat data was utilized as the most economic means to acquire spatially oriented data on four of these criteria: (a) vegetation, (b) land use, (c) surface water, and (d) linear features. Considerations of geologic stability are equally important in the siting of dams and associated water impoundments, and residential communities.

The states of Missouri and Alabama have made extensive use of Landsat data in geologic applications. The Missouri Department of Natural Resources produced a state geologic map and an associated mineral resource map in order to broaden the effectiveness of mineral exploration in the state. As a result of the Landsat application, regional linears in the Missouri lead district were delineated which are possible guiding channels for localizing the ore deposits. Landsat data of the northern half of Missouri has been particularly successful in defining the distribution and limits of moraines and other glacial deposits. The use

of Landsat data in this effort saved several man years of work in planning programs which were designed to map the characteristics of these deposits. In addition, the detection of extensive zones of moisture were useful in updating the knowledge of subsurface geology of the river flood plain. The Alabama Geological Survey developed a statewide geologic linear map and used Landsat to monitor extensive changes to the Alabama coastline and up date coastal zone maps.

One of the most poweful and new capabilities provided by Landsat is the ability to monitor large geographic areas with repetitive coverage and detect significant changes occurring in land cover and subsequently land use. The state of Maryland used this capability to detect and delimit the development of built-up land use in the Baltimore-Washington corridor. The Southwest Florida Municipal Transportation and Urban Development Agency used Landsat as an information source in the production of Existing Conditions Reports and Environmental Impact Statements that are necessary in support of power plant licensing procedures.

The VirginiaState Water Control Board is conducting a pilot program with NASA involving the inventory of land use with Landsat and the evaluation of the impact of improper land use on water quality in Swift Creek Reservoir. In addition, a number of counties in Virginia which are recipients of EPA section 208 Areawide Waste Treatment Program grants have contracted with EarthSat Corporation to use Landsat for the inventory of land use in the region to determine the possible presence of pollution producing land processes.

One of the most common applications of Landsat's capability to detect change in land cover is in the area of strip mining and land reclamation monitoring. The states of Maryland, Tennessee and Alabama have successfully utilized Landsat for the strip mining application. As an example, the State of Maryland enacted a coal strip mining law in 1967 which required the regulation, monitoring and reclamation of strip mines. To perform its regulatory function, the Maryland State Bureau of Mines, needs information on the location, size and condition of coal surface mining areas. In order to obtain this information, the Bureau of Mines used computer-implemented techniques to identify, classify and measure strip-mined lands in Western Maryland. The Landsat based methodology is considered by the Bureau of Mines as an accurate, rapid and cost-effective manner to provide an update and cross reference for field determined mining and reclamation data. The average

accuracy of Landsat measured strip mined lands was 93 percent.

It must be strongly emphasized that the synoptic view and repetitive coverage of Landsat data often provides the only economically feasible means to monitor a large geographic area and detect change on a frequent basis. This capability will become even more significant with the increased spectral sensitivity and spatial resolution of the Landsat follow-on program. Once information relative to this capability is diffused to the law and policy makers' level it will have an impact on the creation of new legislation.

In order to provide a synopsis of the Landsat activities in some sample SGPB member states, the following activity profiles are presented for the states of Texas, Louisiana, and Missouri:

(1) Texas

- A State Remote Sensing Subcommittee has been established by the Texas Natural Resources Information System (NRIS) Task Force to develop an integrated and long range remote sensing plan for Texas as well as to handle daily requests.
- A Systems Central has been established as the point of all user interface with the Texas NRIS. A subset of this organization is devoted to servicing users of remote sensing data. To effectively serve these users, Systems Central has a direct terminal link to the EROS Data Center at Sioux Falls, South Dakota.
- Using a LARSYS terminal, the Office of the Governor, in conjunction with the University of Texas conducted a training program directed toward the use of computer implemented classification techniques. Approximately 70 people from state and regional federal agencies were trained during this program. Follow-on training programs have trained an additional 33 state people.
- As a result of Congressional legislation specifying the inspection of dam safety, Texas used Landsat data as an aid in the inventory of 4240 dams each impounding 50 acre-feet or more of water. With an annual construction of 200 lakes, the Texas Water Development Board is preparing for a periodic inventory update using Landsat.
- The Texas Parks and Wildlife Department developed their own computer classification algorithms to perform an inventory of wildlife habitat in the State.
- Presently, the General Land Office is utilizing Landsat data in the Texas Coastal Zone Management Program. The computer implemented classification techniques

developed for wildlife habitat mapping have been converted and are being utilized, in an information system context, for coastal zone management.
- The Texas Water Quality Board is using Landsat data to monitor land use in river basins and correlate the land patterns with water quality.

(2) Louisiana
- Landsat data were used by Louisiana state agencies to record the levels of the April, 1975 floods and to document Louisiana's request for a major disaster declaration.
- The Louisiana Offshore Terminal Authority has initiated plans to utililize Landsat data in monitoring construction and operation of the Louisiana deepwater port and related land use changes onshore.
- Louisiana, in concert with USGS and NASA is taking steps to incorporate Landsat data into the State's land classification system.

(3) Missouri
- The Interdepartmental Council on Natural Resources Information catalogs remote sensing data, determines user needs and develops educational programs in remote sensing.
- The Missouri Department of Conservation used Landsat data, supplemented with aerial photography to produce an analysis of timber type and production potential, and an evaluation of wildlife and recreation potential in the Grand Platte River Basin.
- Presently, the Soil Conservation Service, the University of Missouri Agricultural Experiment Station and the Forest Service are using Landsat data to develop updated general soils maps of the State.
- Landsat data is used as a way of readily updating land use changes and assisting in verifying any prediction trends by Missouri planners.
- The Missouri Geological Survey has used Landsat data to produce an updated geologic map of the State and a mineral resource inventory. In addition, a mined lands inventory is currently being conducted with Landsat data.

The specific references and activities relating to Landsat were presented in this document to demonstrate the extent and successful nature of Landsat use by member states of the SGPB. In this context, it provides a detailed supporting document to the SGPB resolution passed in support of the Landsat follow-on program.

B (2) PACIFIC NORTHWEST REGIONAL COMMISSION (PNRC)

PACIFIC NORTHWEST REGIONAL COMMISSION
1205 Washington Street
Vancouver, Washington 98660
206 696-2581

II-B(2)

July 15, 1976

Dr. James C. Fletcher, Code A
National Aeronautics & Space
 Administration
Washington, D.C. 20546

Dr. Vincent E. McKelvey
U.S. Geological Survey
Reston, Virginia 22092

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Dear Dr. Fletcher and Dr. McKelvey:

We are writing to express our pleasure at the results of our joint Land Resources Inventory Demonstration Project. The application of the techniques developed under the project will provide our three states with a new, more effective, and less costly source of management data from space age technology - primarily Landsat.

We are now at the midpoint of the three year project in evaluating and demonstrating remote sensing over a wide range of disciplines. Participation in the project includes over 35 agencies and 100 state and local personnel. In the State of Washington, for example, major participants include The Department of Natural Resources, The Department of Game, and The State Office of Community Development, which assists in coordinating local governmental participants. Oregon participants include The Departments of State Forestry, Water Resources, Fish and Wildlife, Land Conservation and Development, Agriculture, and Transportation. Idaho participants include the A.D.A. Council of Governments and the Departments of Water Resources, Lands, Fish and Game, and Agriculturé. In addition, the five major Northwest Universities are active participants.

We believe the project is innovative and unique in both scope and methods and will provide a pattern for other regions. The following is a brief discussion of some of the project's activities and results to date. Initially, the project is exploring application of Landsat data in five disciplines - forestry, agriculture, range, noxious weeds, and urban development. The potential for both monetary savings and improved resources management in these areas was expected to be high. The demonstrations to date support this initial expectation.

In forestry, Landsat data will assist in providing accurate inventories of timber volume. In addition to modernizing procedures that have been highly labor-intensive, thereby reducing the costs of forest management, it allows more timely acquisition of information on forest condition and productivity.

> For example, the Washington State Department of Natural Resources is utilizing Landsat data for a Western Washington Forest Inventory (10 million acres). While this inventory could have been accomplished by standard methods within two years at an estimated cost of $2.0 million, the current estimates indicate that using Landsat data will allow a comparable inventory to be completed in one year at a cost of approximately $200,000.

In agriculture, an evaluation can be made of the extent of irrigated versus non-irrigated croplands, and the crops grouped by water use. This will contribute to more rational and economical use of available water.

> The Idaho Department of Water Resources is using Landsat data for inventorying 4 million acres of irrigated lands along the Snake River. Existing data are up to 10 years old, though spot updates have been made. Approximately 100 people are now employed to gather and evaluate data by present methods. Utilization of Landsat will provide a current data base for more effective management, by monitoring change and providing inputs into water resource models, thus allowing for more effective utilization of the existing manpower.

Landsat data is being used to help the livestock industry reduce cattle deaths by identifying the location and spread of Tansy Ragwort, a noxious weed.

> The Oregon Department of Agriculture has the task of inventorying and controlling Tansy Ragwort in the state. Tansy Ragwort infests some 16 counties in Western Oregon and 10 counties in Western Washington. The losses in livestock alone to this weed are estimated to between 1.5 - 10 millions of dollars per year. Remote sensing is the only feasible method for effectively identifying heavy infestations in remote areas,

> and monitoring of eradication methods. For effective control the areas must be monitored four times per year. The department expects to utilize Landsat data operationally in the monitoring and inventorying of Tansy Ragwort.

In the range discipline it has been found that data can be provided for more efficient stocking and grazing practices by determining range condition and productivity. Furthermore, this information will contribute to a reduced disruption of the ecological balance and improved preservation of wildlife and big game recreational areas.

> The Oregon Department of Fish and Wildlife is using Landsat data in mapping wildlife habitats. The specific application relates to a five-year program to survey the summer habitat of the mule deer. The population of these animals has been decreasing. This decreasing population may be due in part to reduced summer forage. Approximately 1.5 million acres of rangelands scattered throughout the state must be monitored. The Department plans to use Landsat data operationally starting July 1, 1976, specifically for the mule deer summer habitat survey.

Finally, in the urban discipline, efforts are directed toward a determination of the amount of the undeveloped land within city boundaries and an assessment of the rate at which urbanization is encroaching on prime agricultural and forested lands. To the urban planner, this means more efficient and economical land use. To the average man, this holds the prospect of reducing urban sprawl and preserving natural resource areas.

> In Idaho, the Ada County of Governments is using Landsat data to assist in monitoring urban change. A recent survey to update available data on the location and extent of vacant lands in the City of Boise involved 15 full-time workers for a full year and cost \$70,000 using current methods. Annual updates are desired. The same survey was accomplished using Landsat data in one man-month as compared to 15 man-years using current methods. Comparison of results from the two approaches was within 98% accuracy.

Additionally, there is an interesting and significant side benefit to the multifacited nature of this project. We believe it will greatly assist in the transfer of technology to the states. We have involved that "critical mass" of individual agency participants that is a prerequisite to proving the overall value of Landsat on a statewide or regionwide basis. It is that proof that will encourage others to take advantage of the unique benefits to be derived from Landsat. Because of the positive results demonstrated to date, the Land Resources Inventory Task Force is developing a plan for implementing an operational system based on Landsat data. Careful consideration will be given to a gradual implementation process which recognizes the political and financial realities and limitations of agencies, states, and/or regions.

As you are aware, the acquisition of equipment and changeover to a new data base can be an expensive proposition, particularly for states. While increased capability (resolution, etc.) is always important, the most critical element is continuity of data. Without assurance of continuity, states cannot accept the risks of utilizing Landsat data as a primary tool, valuable though it is. Accordingly, because we believe the results to date have demonstrated conclusively the value of remote sensing, the commitment to a continuous Landsat program is essential to meet the needs not only of our region, but of other states as well.

We would like to extend an invitation for you to visit the Pacific Northwest to view for yourself some of the Landsat applications.

Sincerely,

PACIFIC NORTHWEST REGIONAL COMMISSION

Governor Robert Straub	Jack O. Padrick
State Cochairman	Federal Cochairman

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AMERICAN REVOLUTION BICENTENNIAL 1776-1976

TENNESSEE VALLEY AUTHORITY
KNOXVILLE, TENNESSEE 37902

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EDM

Rec'd in [illegible] 6/30
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Suspense [illegible]
Prepare Reply for Signature of

June 22, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
Washington, D.C. 20546

Dear Dr. Fletcher:

The Tennessee Valley Authority has made a commitment to implement an operational earth resources information system which will enable TVA to efficiently utilize spatial data for regional planning, siting, and assessment activities during the 1980's. An integral part of this system will be information derived from Landsat data. Our use of the completed system will be in the area of broad natural resource planning, forest land management, forest industry siting, power facilities siting, and environmental assessment work. It is critical to the current planning and design phase of this system that there be continuing availability of earth resources data from Landsat-type satellites through the 1980's. Furthermore, there is a need for increased spatial and spectral resolution.

One of the recent successful uses that TVA has made of Landsat data has been in the area of EPA 208 Water Quality Planning in cooperation with the Knoxville Metropolitan Planning Commission. Although Landsat information was found useful for determining broad land-use classes, there was a need for finer spatial resolution such as that proposed in the Landsat follow-on program of 30 meters. In urban areas this resolution is critical in pinpointing development problems in settings where ownerships and land uses have a high degree of diversity.

TVA has successfully used Landsat data in the past for determining broad classes of forest types as an aid in preparing forest management plans. To efficiently use this data, however, there is a need for further breakdown of forest types by species rather than the broad categories of hardwoods and conifers. This will be possible through the increased resolution proposed with the Landsat follow-on--particularly the three near-IR bands.

Through both experimental and operational work utilizing our own thermal scanner, TVA has shown the feasibility of using thermal IR data for environmental monitoring of steam plants. An addition of a thermal IR channel in the Landsat follow-on program should enable TVA to more effectively detect and monitor sudden changes in water temperatures across the Valley in a timely manner.

Dr. James C. Fletcher June 22, 1976

TVA presently has a remote sensing section within its Division of Water Management. Arrangements have been initiated for institutionalizing the mechanism for utilizing Landsat data within TVA and with Valley cooperators. The success of TVA's planning for an earth resources information system is dependent to a large degree upon the commitment by other agencies, such as NASA, to continue providing remote sensing data in the next decade; i.e., the Landsat follow-on program.

Sincerely,

John S. Barron
Assistant to the General Manager
(Planning, Budget, and Systems)

CC: Mr. Russell L. Schweickart
NASA Headquarters
Director of User Affairs, Code EK
Washington, DC 20546

Action Copy to E
Info Copy to A, AD
AA, ADA
A26611
Rec'd in NASA 6-28-76
Suspense Date NONE
Prepare Reply for
Signature of

STATE OF UTAH
OFFICE OF THE GOVERNOR
SALT LAKE CITY

CALVIN L RAMPTON
GOVERNOR

July 7, 1976

Action Copy to E
Info Copy to A, AD, AA, ADA, AC, B
A 37268
Rec'd in NASA 7-22-76
Suspense Date 8-2-76
Prepare Reply for
Signature of

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters - Code A
Washington, D.C. 20546

Dear Jim:

I am writing to convey the endorsement of the states comprising the Federation of Rocky Mountain States for NASA's proposed LANDSAT follow-on program.

The Federation currently has underway a well-coordinated NASA-funded LANDSAT project using a digital satellite and ground-source data to conduct land use analysis. This new approach to acquiring and analyzing land use data provides planners in the region an inexpensive and objective source of data for developing a regional land use inventory.

The proposed capabilities of the LANDSAT follow-on program would provide additional benefits through increased amounts of information supplied in more varied and usable form and on a continuing basis. The vast expanses of this Rocky Mountain Region unquestionably lend themselves to the use of remote sensing techology. The resolution of new problems facing this region as a result of the energy onslaught in the Rocky Mountain states requires the application of LANDSAT and its associated technologies.

Therefore, I am authorized by my colleagues in the Federation to indicate our desire to see the LANDSAT follow-on become a permanent part of the federal government's data collection efforts. This will allow our states the opportunity to continually utilize this information as a part of our planning and policy making process.

You will be pleased to know that our regions assessment of the LANDSAT program as one of the most significant achievements of the U.S. space program is concurred in by the National Governors' Conference which earlier this month adopted the enclosed resolution at our annual meeting.

Sincerely,

Calvin Rampton
Governor

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D.- 34

LANDSAT FOLLOW-ON PROGRAM

THE GOVERNORS ARE BECOMING INCREASINGLY AWARE OF THE SIGNIFICANCE AND IMPORTANCE OF THEIR TIMELY NATURAL RESOURCES MANAGEMENT DECISIONS. THESE DECISIONS ARE BECOMING INCREASINGLY COMPLEX AND DIFFICULT DUE TO SUCH FACTORS AS GROWING COMPETITIVE DEMAND FOR RESOURCES, DWINDLING AVAILABILITY OF KEY RESOURCES, INCREASED RATE OF RESOURCE UTILIZATION, THE EXPANDING REGIONAL NATURE OF DECISIONS AS WELL AS RESULTING IMPACTS, AND THE NECESSITY TO ACHIEVE THE DESIRED BALANCE BETWEEN ECONOMIC WELL-BEING AND ENVIRONMENTAL QUALITY.

STATE, REGIONAL AND LOCAL RESOURCE MANAGERS ARE INCREASINGLY LOOKING TO REMOTE SENSING TECHNIQUES, AND IN PARTICULAR THE LANDSAT PROGRAM, AS AN IMPORTANT NEW TECHNOLOGY THAT CAN MAKE A SIGNIFICANT CONTRIBUTION TO THE INFORMATION BASE REQUIRED FOR IMPROVED RESOURCES MANAGEMENT. THE IMPROVED AND TIMELY RESOURCE DECISIONS RESULTING FROM THE AVAILABILITY OF LANDSAT-GENERATED DATA HAVE IMMEASURABLE BENEFITS. THESE BENEFITS INCLUDE IMPROVED RESOURCE MANAGEMENT, MAINTENANCE OF ENVIRONMENTAL QUALITY, AND THE REDUCTION OF FUNDS AND RESOURCES WASTED AS A RESULT OF DELAY AND LITIGATION ASSOCIATED WITH UNRESOLVED LAND MANAGEMENT ISSUES.

THE GOVERNORS, THEREFORE, RESOLVE TO SUPPORT THE LANDSAT FOLLOW-ON PROGRAM IN ORDER TO ASSURE CONTINUED AND IMPROVED DATA FOR USE IN NATURAL RESOURCE DECISIONS BY THE STATES.

Southern Governors' Conference

3384 PEACHTREE ROAD, N.E. • SUITE 610
ATLANTA, GEORGIA 30326

SECRETARIAT:
THE COUNCIL OF STATE GOVERNMENTS
SOUTHERN OFFICE
404/266-1271

October 15, 1976

Action Copy to EK
Info Copy to ER
E, ED
ED-M

Rec'd in Code E 10/21
Control Number E-960
Suspense Date 10/28
Prepare Reply for
Signature of A

Dr. James C. Fletcher
Administrator
National Aeronautics and
Space Administration
400 Maryland Avenue, SW
Washington, D. C. 20546

Dear Dr. Fletcher:

It is my pleasure, as Chairman of the Southern Governors' Conference to enclose a copy of that Conference's resolutions adopted September 1 in Williamsburg, Virginia.

I call attention to Resolution No. 7, "The Landsat Follow-On Program."

My best wishes.

Sincerely,

Mills Godwin Jr.

Governor of Virginia

MEG/sek

Enclosure

Action Copy to E w/ encl.
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A-29252 ADA
B, K, K
Rec'd in NASA 10-20-76
Suspense Date 11-4-76
Prepare Reply for
Signature of A

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And further, the Southern Governors' Conference urges the Congress, the Administration, and the states to take steps to effect needed coordinated public transportation, to eliminate unnecessary duplication among service providers, and to improve public mass transit's effectiveness and efficiency.

6. POLICIES TO IMPROVE ANALYSIS AND REVIEW OF REGULATIONS FROM THE U. S. DEPARTMENT OF TRANSPORTATION

The U. S. Department of Transportation, Office of the Secretary, on April 16, 1976 issued new procedures to improve analysis and review of existing of future regulations. These new procedures require divisions within the U.S. DOT to evaluate anticipated impacts of new regulations on all parties involved, to use this evaluation of new regulations to determine their desirability and to include a brief summary of the evaluation and analysis in the notice of proposed and final regulations. Further, any potentially costly or controversial regulations must be submitted 30 days in advance of a notice or proposed rule-making to the Office of the Secretary for evaluation. Finally, each division within the U. S. DOT must establish structured processes for parties affected by existing regulations or grant programs to assess and recommend changes.

The Southern Governors' Conference believes that the internal evaluation procedures for new regulations are a positive step toward minimization of promulgation of unnecessary, burdensome, or poorly conceived regulations. These procedures may, in the future, reduce the red tape and over-regulation of programs and projects in which the States participate.

In addition, the Southern Governors' Conference believes the opportunity for the States and other involved parties to assess and review existing rules and regulations to accommodate changing circumstances and conditions will be very beneficial for all parties concerned. This procedure will enhance intergovernmental relations and permit the Federal government periodically to receive input from the actual "implementors" or users of federal programs and find which rules, regulations, or grant programs are or are not working and why.

The Southern Governors' Conference fully supports these concepts to reduce the probability of unwieldy and unneeded rules and regulations and compliments the Secretary of Transportation on his efforts to implement these changes. The Southern Governors' Conference believes a tremendous improvement in these procedures could be achieved by permitting the States and other involved parties to participate in initial U. S. DOT departmental evaluations and assessments of new regulations to complement development of the states' participation in review of existing regulations.

7. THE LANDSAT FOLLOW-ON PROGRAM

WHEREAS, the demand for and utilization of natural resources is constantly increasing due to an increased population and an increased role of consumption per individual; and

WHEREAS, the supply and quality of natural resources are finite; and

WHEREAS, the Region and the States comprising the Southern Governors' Conference are experiencing significant and rapid population growth and development; and

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WHEREAS, the Southern Governors' Conference has taken a strong interest in the proper management of the South's natural resources and has identified specific recommendations directed toward optimizing the regional growth and achieving the desired balance between economic development and environmental quality; and

WHEREAS, there is a keen awareness by the Governors of the significance, increasing complexity and lasting impact of decisions which are made relative to the use of natural resources in the South; and

WHEREAS, the Southern Governors' Conference recognizes that an essential requirement for improved decision-making and intelligent resource management is an effective information base; and

WHEREAS, the Governors strongly believe, on the basis of previous experience, that the type of information obtained by remote sensing technology from the Landsat program is extremely useful to the States in providing the information necessary for the analyses of their natural resources; and

WHEREAS, the Governors have indicated a strong interest and intention to use Landsat data to assist their resource management programs in the future, and they support the expansion of the technology transfer capacity at NASA's Earth Resources Laboratory:

NOW, THEREFORE, BE IT RESOLVED that the Southern Governors' Conference hereby strongly endorses the continuation and improvement of the NASA Landsat system through the implementation of the Landsat follow-on program and associated user assistance and technology transfer efforts as a key step in the provision of improved and cost effective remotely sensed information required by the States to manage their natural resources effectively.

8. CLEARINGHOUSE OF CORRECTIONS AND MENTAL HEALTH INFORMATION

Because of fast-breaking developments in areas affecting Corrections and Mental Health systems, a valuable service could be provided states by the establishment of a "Clearinghouse of Corrections and Mental Health Information." This body could be utilized by state policy-makers, administrative agency heads, Attorneys General and others to exchange information on such areas as new litigation, court rulings, techniques in solving mutual problems, and programmatic ideas.

The Southern Governors' Conference asks that its incoming Chairman explore, and if found feasible, implement a mechanism to provide states of this region with needed information concerning new developments in the area of Corrections and Mental Health systems.

9. RESPECTIVE STATE/LOCAL/FEDERAL ROLES IN RESOURCE MANAGEMENT

State and local governments have historically retained responsibility and jurisdiction for planning and management of the utilization and development of physical or land resources within the various states, that are held privately and/or by state and local governmental units and entities.

C. INDIVIDUAL STATES

STATE OF ALABAMA

GOVERNOR'S OFFICE

MONTGOMERY

GEORGE C. WALLACE
GOVERNOR

April 2, 1976

Dr. James C. Fletcher
Administrator
National Aeronautics and
Space Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

The State of Alabama has always received outstanding support from the National Aeronautics and Space Administration and, in particular, from the Marshall Space Flight Center in all mutually compatible programs. We are presently engaged in programs requiring the use of satellite derived information. Since Landsat 1, we have used data made available to us in our state planning program.

It is difficult to quantify the benefits accrued or project in terms of cost savings because the availability of this information on a recurring basis will allow us to do things we could not do otherwise. Some of these include landscape change detection, monitoring resource development, monitoring forest and agricultural practices and monitoring environmental impacts.

We are in the process of developing a land use system based on Landsat data. This system will combine ground-truth data, aerial photography data and Landsat data. This system is being developed through the joint cooperation of the MSFC, Auburn University and the Alabama Development Office.

While, as I mentioned previously, it is difficult to quantify the benefits received from the use of the Landsat data, I believe these benefits are significant. Development in the area of land use planning is proceeding at a deliberate pace. But one of the many benefits that is difficult to pinpoint is the development of land use planning skills within state government through the effort of building such a system. I strongly support the Landsat-C and the Landsat follow-on. I think both are necessary and the improved resolution will add greatly to the utility of the information.

Sincerely,

George C Wallace

George C. Wallace
Governor

GCW-r
cc: Dr. Wm. Lucas, MSFC

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STATE OF ALABAMA

ALABAMA DEVELOPMENT OFFICE

GEORGE C. WALLACE
GOVERNOR

R. C. "RED" BAMBERG
DIRECTOR

W. M. "BILL" RUSHTON
ASSISTANT DIRECTOR

July 30, 1976

Action Copy to EK
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ED
E

8/6
E-486
8/16
E

Dr. James C. Fletcher
Administrator
National Aeronautic & Space Administration
Code A
Washington, D. C. 20546

Dear Dr. Fletcher:

I would like to take this belated opportunity to express a few brief thoughts and my support of the continuation of the "Landsat" program. For several years I have watched the evolution and progress of this program. In the beginning of this program the possibilities existed for the acquation of information we have never had before. The earth resources satellite program was very timely. There has been a growing concern over the past few years about our finite natural resources and the growth and development of society. There is no doubt that we do not have the information nor the tools to acquire the information needed in dealing with future growth and demand for resources. The "Landsat" program offers us some renewed hope in dealing with growth and development in the future.

Our first look at the picture like information from "Landsat" was immediately useful in providing a new perspective of our State. These products continue to provide a frequent overview of the area. However, perhaps the most useful product from the program is the analysis potential available through the digital tapes. Even though we do not have the present capability in our office to work with the digital information, there is no doubt that this could assist us in many functions called for in our charter. This includes land use, and natural resources development and planning, monitoring of urban growth, etc. In addition to uses by my agency it appears that this same data can provide needed inputs to many other state agencies in Alabama.

Recently I participated as one of six members of a technical subcommittee to advise the National Conference of State Legislatures on the satellite remote sensing program in state government. Enclosed is a copy of a brief presentation I made to this group. The members of the subcommittee agreed to discuss different aspects of utilization of the satellite acquired data. From the briefing given, there appears to be a universal expression and agreement of the many beneficial uses of the information derived from the satellite.

There also seemed to be universal agreement as to the reason that more state governments have not taken advantage of the satellite program. These include as stated in the attached presentation:

3734 ATLANTA HIGHWAY • MONTGOMERY, ALABAMA
MAILING ADDRESS: STATE CAPITOL • MONTGOMERY, ALABAMA • 36130
(205) 832-6810

1. The lack of a committment of the federal government (NASA & Congress) to establish the "Landsat" program as an ongoing or operational effort. If the states established the capability, skills and equipment needed for the use by states of the digital tapes, there must be more of a committment that a continual supply of source data will be available otherwise in the present mode (experimental) the states may be left holding the bag.

2. The "Landsat" program is still experimental, methods of analysis and equipment are still being developed. This also makes the states reluctant to establish one of the present systems.

3. There is also an inability to develop an organized effort at the state level to provide a framework in which all state agencies with experience, knowledge or need for the use of the satellite acquired data, to pull together in a common effort for the implementation of the analysis techniques required.

There appears to me to be an important missing link in the development of the satellite program for state governmental use. This is an intermediate step in the transfer of this technology to state governments. The present flow of technology is from a limited experimental mode directly to operational systems in state goverrnment. This, in my opinion, is ridiculous to expect state government to take this high degree of technology directly from experimental procedures. Many states and state agencies including those in Alabama have not even become comfortable with computers. I suggest that in the future NASA consider the establishment of regional centers. Manned and equipped with the technology needed to allow state governmental agencies to go to, bring their own tapes, and be able to leave with a usable product. After the states get experience with the system and show what it can do, I believe they will establish the system in their own states.

The ADO has for the past few years been involved in the development of a system that has the capability of relating various types of geographic information. It was anticipated that satellite acquired data would provide one of the major sources of information. Even though we have not implemented the system needed to provide the link for the satellite acquired data, it was developed with this in mind. The analysis system appears to be working well with data derived from other sources. However, the addition of the satellite capabilities would make it much more useful.

Sincerely yours,

Wolfram U. Drewes
Resource Planner
Agriculture and Rural Development
Department

Dr. Fletcher
Page three
July 30, 1976

In summary, I again would like to express my support in the continuation of the "Landsat" program and hope it will become an ongoing system.

Sincerely,

W. B. Stevenson

Walter B. Stevenson
State Planning Division

WBS/db

Enclosure Not retained in AE11-3

cc: Mr. Russell R. Schweickart
Code EK

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A-27622 ADA,
AC, B
Rec'd in NASA 8-4-76

Suspense Date 8-18-76
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Signature of E

C-2

CAN THE USE OF SATELLITE REMOTE SENSING ASSIST ALABAMA IN OBTAINMENT OF ITS GOALS?

by

Walter Stevenson
State Planning Division
Alabama Development Office
Montgomery, Alabama

for

The Task Force on Uses of Satellite Remote Sensing for State Policy Formulation, National Conference of State Legislatures, June 30, 1976, Annapolis, Maryland.

CAN THE USE OF SATELLITE REMOTE SENSING ASSIST
ALABAMA IN OBTAINMENT OF ITS GOALS?

Can the use of satellite remote sensing assist the State of Alabama in obtaining its goals? The answer to this question is yes and no. There is no doubt based on my understanding of the technical capabilities that have been developed, that the satellite can be useful in my state. There is also the realization that it can not do everything for all people and interests.

Some of the varied applications I foresee as useful in Alabama include:

1. land cover identification and change detection;
2. strip mine applications;
3. pollution identification, this application appears to be marginable with existing sensors, but those planned for the future should make this application one of the most interesting;
4. forest insect and desease detection;
5. wetland mapping and monitoring;
6. erosion detection of coastal area;
7. geologic applications;
8. natural disaster damage assessment; and,
9. other applications.

In specifics I will duscuss several of the interesting applications that have been made in Alabama. Many of the applications of satellite acquired information are common among the states for example land cover identification and change detection, strip mine applications, etc. Some of which will be discussed by others here today. Therefore, I will not go into these except to say that most appear to be usable and helpful to the requirements for information needs in the State.

Alabama for several years has been interested in the applications that might be made with the data acquired from satellites. The Geological Survey of Alabama has been a leader in the use of satellite acquired data in Alabama. In 1969, the Geological Survey of Alabama used images from the Apollo 9 mission in an experimental mode to determine if this type of data could be of any use. Several important uses were identified from this data. Perhaps the most important finding was the location of relatively straight, long, lineaments that were unknown before this type of source material was available. It appears that the lineaments "reflect topographic and vegetative differences, which in turn may be related to the fracturing of the bedrock." The Geological Survey of Alabama determined that a relationship existed between the location of the lineaments and the location of high yield springs and wells. This provided a link between the data acquired by satellite and the conventionally derived information on water yields. This type of application is extremely important to the overall development of the State. It is impossible to place a dollar figure on this type of use. It identified the occurance of geologic conditions that we did not know about before the satellite and it would most likely have been years, if ever, before this condition was discovered.

One of Alabama's most important Goals is to raise the per capita income of its citizens and broaden its economic base. The location, availability of and understanding of our water resources is a major contributing factor to this goal. The satellite acquired data can assist in the identification of new sources of sub-surface water supplies.

Another interesting find relative to the identification of lineaments in Alabama was the presence of a lineament that passed directly across the site of Logan Martin Dam (15,000 acres.) For many years there had been leakage at this

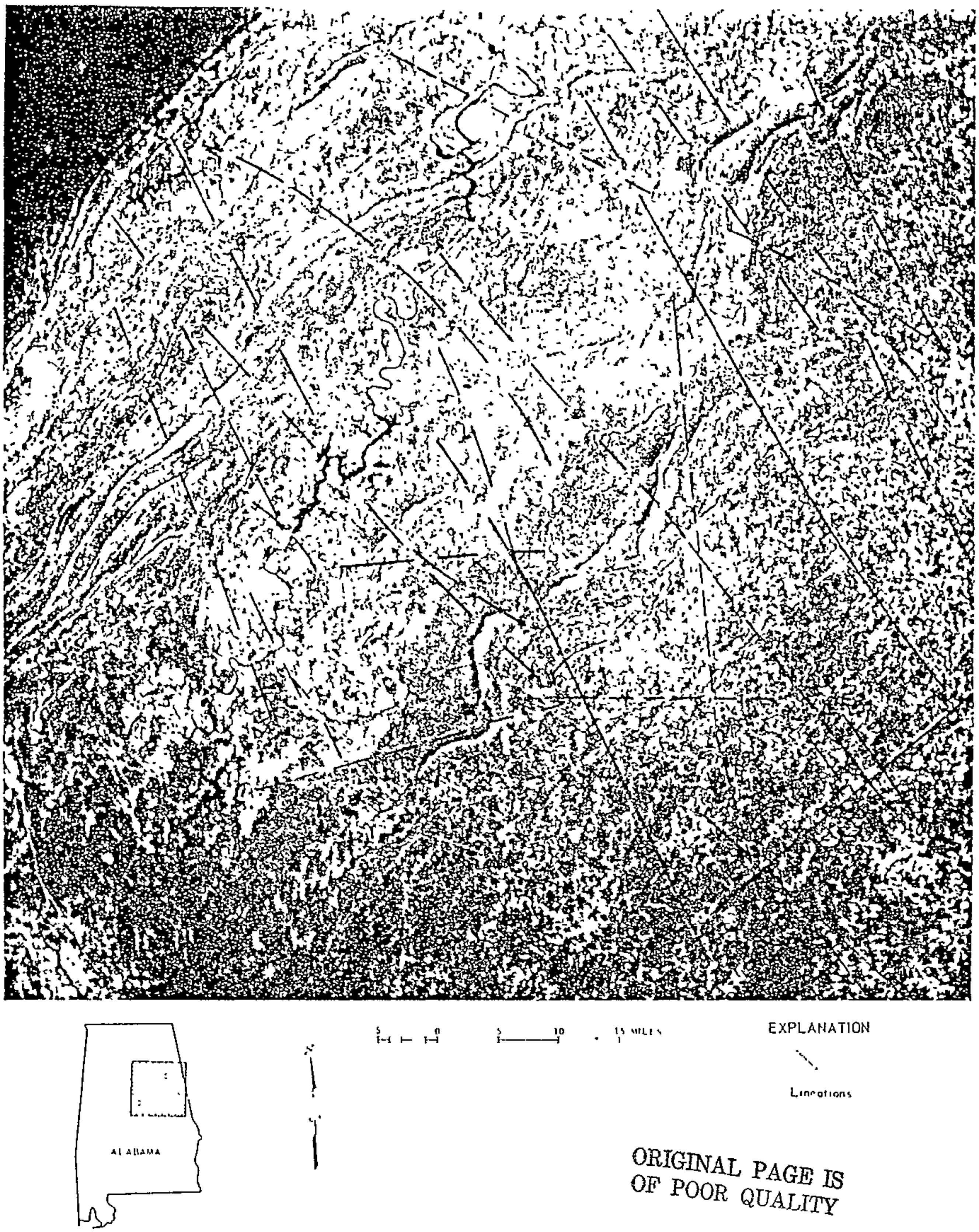


Figure 9.—Principal lineations.

dam site. All efforts to stop the leakage have failed. After the lineament was discovered various tests were made that confirmed the existence of an interconnected solution feature that coincided with the location of the lineament. The Geological Survey now believes that this leakage was caused by "preferred dissolution of the dolomite of the underlying formation along a fracture zone."

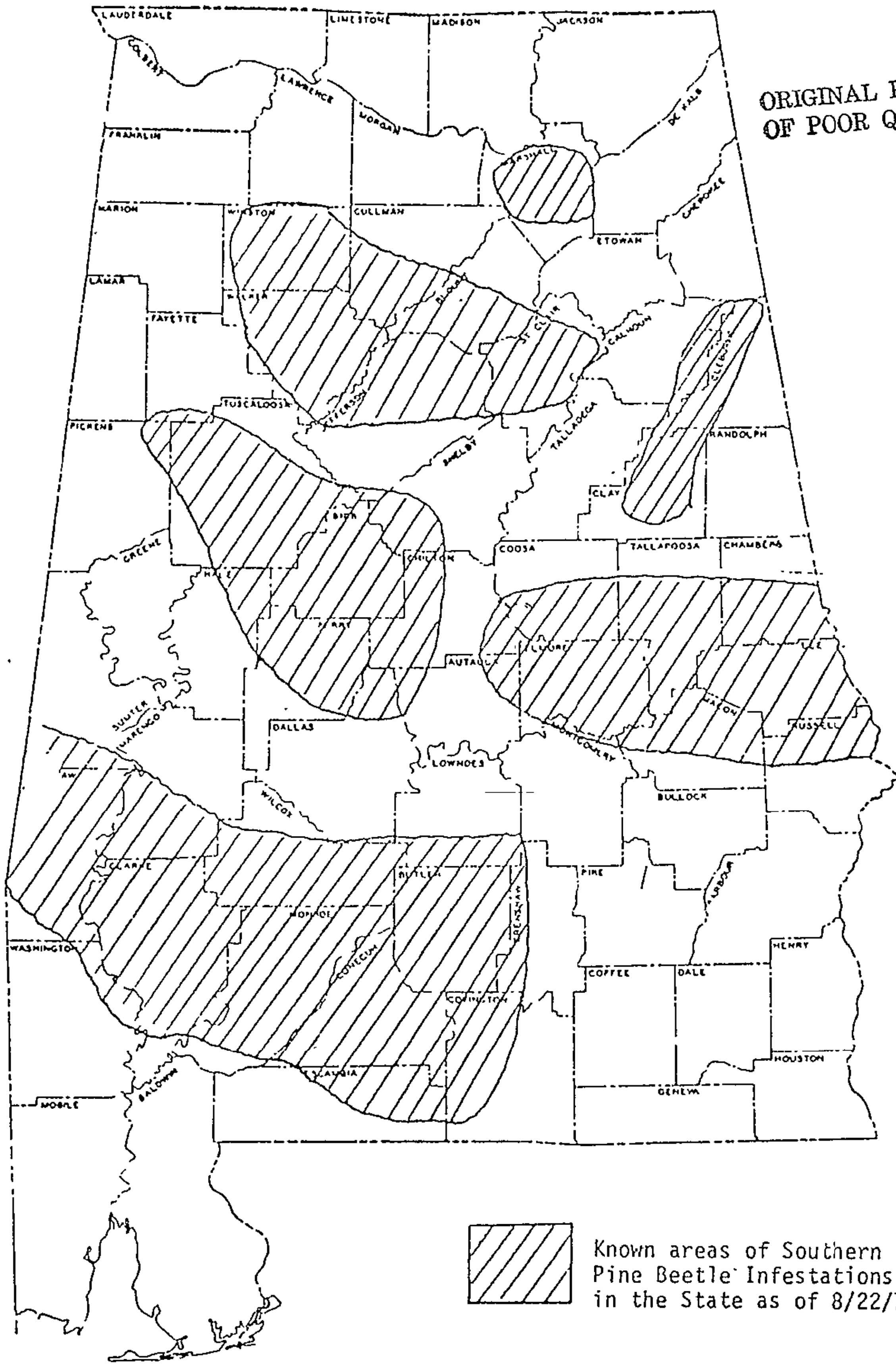
There is a great deal of interest in using the satellite acquired data in future investigation related to the siting of major facilities such as dam, power plants and bridges. This type of use like so many more is an example of providing new information from which hopefully we will be better able to plan the development of the state. There is also the possibility that this type of information can prevent potential disaster such as dam failures. We had a major break in a new dam a few years ago. The final decision on the cause has not been determined. In the dam break in Alabama luckily there was no loss of life; however 18% of Alabama Power Company's hydrogenerating capacity was lost. There is no telling when this facility will be rebuilt. With the continued increase in urban growth in areas of potential damage and the increase in the need for energy facilities there is a corresponding increasing need for new methods and effort in facilities siting.

Another interesting application of satellite acquired data was the delineation of the length of the coastline of Alabama. The Alabama shoreline is constantly changing. Conventional methods do not fulfill the repetitive and time factors required. The recorded length of the coastline is important to the State. Until recently the methods most often employed were related to the measurement of the shoreline length from existing maps. These maps or charts are not often updated and the methods used and the scale

of the map, makes a realistic measurement virtually impossible. Official records indicate that the State's shoreline was about 350 miles in length. Through the use of Landsat computer compatible tapes a method was developed that can accurately determine the shoreline length. This method yielded a length of 811 miles compared to about 350 miles using conventional methods. This method will also yield the identification of areas of change in the shoreline by comparing different time frames and using the consistent methods of analysis. This use has a potential application of being used in the allocation of funds for coastal management.

The last application I will mention is one that has not proven completely possible through the use of the existing satellites, however, the capabilities proposed for the Landsat follow-on beginning in the 1980's will make this application possible. The use that I am referring to is the detection of the Pine Beetle in the pine forest of Alabama. The Pine Beetle is an insect that boars under the bark of the pinetree and in a short time is able to kill the tree. The Pine Beetle can produce as many as five generations in a single year. This insect has been called the most widespread and destructive insect in the South. It particularly likes the loblolly, slash and the Virginia pine stands. The only effective control is the detection of effected stands of trees and immediate removal of the tree.

The key to the effective control is the prompt detection of the beetle. Within Alabama we have about 70% of the total land area covered in forest and the majority is in pine. The forest industry is one of the largest in the State. It has been proven that the use of color infrared photography from an aircraft platform was the most useful method available for the



Known areas of Southern Pine Beetle Infestations in the State as of 8/22/72

detection of areas infested with the Pine Beetle. But it is economically impossible to get the large scale repetitive coverage needed to use this method of detection. An attempt was made to see if the existing Landsat data could be used to overcome this problem. The tests results were marginable with existing Landsat capability. However, it is felt that the additional capability proposed in the satellite system proposed for the 1980's will provide this capability.

In the above comments on specific uses of the satellite data in Alabama I have tried to focus on some unique uses being made by state agencies to state problems. I have not gone into detail on the more common uses such as land cover identification, strip mining, wet lands monitoring and other applications.

Currently the agencies of the State of Alabama have not been able to develop an ongoing satellite data analysis capability. This can be attributed to several reasons including:

1. The lack of a committment of the federal government to identify the satellite programs as an ongoing or operational effort. If the State established the skills and equipment needed for the operational use there must be more of a committment from the federal government that a continual supply of source data will be available. If the state were to go ahead and establish this capability and the satellite program were dropped then the expenditure and training of people would be of little use.
2. The satellite program is still experimental and methods of analysis are still being developed. This makes states reluctant to establish

one of the present systems.

3. The inability to form an organized effort at the state level to provide the framework for all state agencies to support a single facility. There are several agencies in Alabama with experience or knowledge of the possible uses of the satellite acquired information, however, to date the concerned agencies have been unwilling to pull together in a common effort. This problem may soon be resolved by reorganization within state government.

In closing I would like to state that efforts are currently underway and nearing completion to develop an automated method of relating the information that can be derived from satellite acquired sources with information from conventional methods. This is being undertaken in the Alabama Development Office as a first step in anticipation of integrating the satellite information into the state planning process as an ongoing effort. If we are to cope with the existing and future problem of growth, resources production, pollution, etc. we must look to better ways to acquire information. The continueation of the Landsat program can greatly assist State government in this endeavor.

GEOLOGICAL SU...

PHILIP E. LAMOREAUX
State Geologist and Oil and Gas Supervisor

W. EVERETT SMITH — Assistant State Geologist, Operations
GEORGE W. SWINDEL, JR. — Assistant State Geologist, Administration

A. CHARLES FREEMAN
Attorney

P. O. Drawer O
...ersity, Alabama 35486
Phone (205) 759-5721

MINERAL RESOURCES
T. L. Neo
WATER R...
R. L. L...
ENERGY RESOURCES
P. A. Boone, Chief
GEOLOGY
C. W. Copeland, Jr., Chief
ENVIRONMENTAL
R. L. Chermock, Chief
GEOCHEMISTRY
N. A. Lloyd, Chief
WATER QUALITY RESEARCH
A. M. Malatino, Chief
REMOTE SENSING - TOPOGRAPHY
C. D. Sapp, Chief
PUBLICATIONS
T. V. Stone, Chief

II-C(1-4)

March 29, 1976

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Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration
Washington, D.C. 20546

Dear Dr. Fletcher:

I have been asked by Dr. P.E. LaMoreaux, State Geologist, to respond to your request for comments with reference to the sensing capabilities of the planned Landsat-C follow-on (Landsat-D). My comments address the general requirements in geology, hydrogeology, and associated disciplines.

The spectral bands and visible band spatial resolution listed on the attachment appear adequate for our needs. The need for the 0.80-0.91 micrometer near-IR bands is not clear to us, as most of that information will be available in the 0.74-0.80 micrometer band.

The 30-meter resolution value will be adequate if this figure represents normal contrast rather than high contrast scenes in the visible channels. Ideally, we are looking for resolution on the order of 10-12 meters but realize the technical problems in handling such a quantity of data. The 120-meter IR resolution in the two thermal channels is still inadequate but is a great improvement over currently available thermal data from meteorological satellites.

The 11:00 AM Local Solar Time pass should be shifted to either shortly after mid-day or midnight at which time maximum temperature excursions should be observable to support thermal inertia studies. However, such a time would not be best for the visible channel, as geological interpretation benefits from low sun angle scenes. We suspect that the 11:00 AM pass time is probably a trade-off but it may compromise the value of both channels. Perhaps the two channels should not be carried on the same platform?

Finally, the Geological Survey of Alabama recommends that coordinated field work be funded to strengthen the analytical or interpretive link in the system. NASA's technology can benefit the user only insofar as the geoscientist can use the data, and it appears that this link is the weakest. The State level should remain involved in the satellite imagery program and field data gathering is best done at this level. We appreciate your interest and welcome the opportunity to respond to this request, which came to us through the Earth Resources Office at Marshall Space Flight Center.

Yours truly,

C. Daniel Sapp, Chief
Remote-Sensing/Topography Div.

CDS/pqc

Attachment

xc: C. T. Paludan, NASA
F. L. Doyle

School of Graduate Studies
And Research

Center for
Environmental Studies

The University of Alabama in Huntsville

P.O. Box 1247
Huntsville, Alabama 35807

II-C(1÷5)

March 24, 1976

Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

ORIGINAL PAGE IS
OF POOR QUALITY

Dear Dr. Fletcher:

Associates of mine at Marshall Space Flight Center have asked that I comment on the Landsat C Follow-on with regard to its application to hydrology.

The 10.4 - 12.5 micron band seems to have the best potential for use in ground water hydrology. Although its 120 meter resolution is rather broad, the thermal infrared imagery could be a valuable tool for making subsurface interpretations in ground water hydrology. The same band could also be useful in surface water hydrologic studies, especially where thermal plumes enter large standing bodies of water.

If a finer resolution were possible (say 40 to 60 m.) that would be highly desirable for the ground water work, but even as presently specified the thermal imagery seems worthwhile. I hope it will be included.

Thank you for the boost to research that space technology gives.

Cordially,

F. L. Doyle

F. L. Doyle
Adjunct Professor of Hydrology

Action Copy to E
Info Copy to B, BD,
BB
A-30748 BDA
Rec'd in NASA [illegible]
[illegible]
Prepare Reply for
Signature of E

Rec'd [illegible] 4/5
[illegible] E-[illegible]
4/9
[illegible] E

ROBERT W. HIATT
PRESIDENT

UNIVERSITY OF ALASKA
OFFICE OF THE PRESIDENT
FAIRBANKS, ALASKA 99701

Action Copy to EK
Info Copy to ED
ED-M
ER

July 7, 1976

Rec'd in Code E 7/15
Control Number E-420
Suspense Date 7/23
Prepare Reply for Signature of A

Dr. James C. Fletcher, Administrator
National Aeronautics & Space Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

I want to lend my support to a NASA program that is important to the University of Alaska and the community it serves. Tremendous benefits from the earth-resources program have accrued to those agencies, both federal and state, which manage and control the resources in Alaska, and also to private industry whose activities develop these resources for the benefit of the nation. The attached list of agencies that cooperate with the University's Geophysical Institute in applying ERTS and Landsat data testifies to the ready market for data presently generated by NASA's earth-resources program.

It is highly desirable that we maintain our momentum into the 1980's with an improved satellite data acquisition system designed for operational use of earth-resources data, analogous to the routine applications presently being made by the National Weather Service for meteorological satellites. Improved sensors in an earth-resources satellite plus a network for the speedy dissemination of the space-acquired data should be on our drawing boards now. I am gratified to learn that NASA is preparing to do this, so that we may look forward both to continuity in geographic coverage and to improved sensors.

At the University of Alaska we have watched with interest and approval the growing maturity of your technology. Like any institution with demands that exceed available resources, this University must closely examine all proposed programs in instruction and research to ensure that each activity meets a continuing demand. Because of the importance of space data to the geology of Alaska, we have recently added two courses of instruction in remote-sensing techniques to the geology curriculum. Further, to meet the demand for data reproduction, analysis and interpretation, we have recently committed ourselves to adding two more professional staff specializing in remote-sensing applications in ecology and applied research. These are in addition to the three faculty and professional staff members in this field.

Certainly, we believe in the future of remote-sensing technology as applied to the management of resources. The University of Alaska has extended itself to accommodate this growing new technology that shows great promise for Alaska and which has already yielded gratifying results. The University is pleased to endorse and encourage the plans for the NASA follow-on to the Landsat program.

I wish you every success.

Sincerely,

Robert W. Hiatt

Robert W. Hiatt
President

RWH:dm
Enclosure

cc: Dr. Mather

Action Copy to E w/enc
Info Copy to A, AD
AA
ADA
B
A-27037
Rec'd in NASA 7-13-76
Suspense Date 7-28-76
Prepare Reply for Signature of A

Cooperating Agencies

Federal Government Agencies

U.S. Army Corps of Engineers
USDI/Bureau of Mines
USDI/National Park Service
DOT/Federal Highways Administration
DOT/Federal Aviation Administration
U.S. Air Force/Alaskan Command
U.S. Coast Guard
USDI/Bureau of Indian Affairs
USDI/Bureau of Sport Fish & Wildlife
USDI/Alaska Power Administration
NOAA/Auke Bay Fisheries Laboratory
NOAA/National Weather Service
NOAA/Environmental Research Lab
USN/Naval Arctic Research Lab
Federal State Land-Use Planning Comm.
USDA/Soil Conservation Service
USDA/Forest Service
USDI/Bureau of Land Management

Regional & Local Government Agencies

City of Nenana
City of Fairbanks
Fairbanks North Star Borough
City and Borough of Juneau
Greater Anchorage Area Borough
Kenai Peninsula Borough
Ketchikan Gateway Borough
Matanuska-Susitna Borough
North Slope Borough

State Government Agencies

Department of Highways
Department of Fish & Game
Department of Education/State Library
Dept. of Natural Resources/Geol. Survey
Dept. of Natural Resources/Div. of Lands
Dept. of Economic Devel./Indust. Devel.
Dept. of Public Works/Div. of Aviation
Dept. of Environmental Conservation
Office of the Governor/Planning & Research
Department of Public Safety

Other Organizations

Kross & Associates
Woodward, Lundgren & Associates
Alyeska Pipeline Service Company
CH_2M/Hill Alaska, Engineers
Lost River Mining Corp., Ltd.
Humble Oil & Refining Company
Woodward-Envicon Inc.
Environment/Alaska
Resource Associates of Alaska, Inc.
U.S. Steel Corporation
Marathon Oil Company
Tanana Chiefs Conference
NANA Regional Corporation
Arctic Environmental Information & Data Center
Fisheries Extension Service
Northland Wood Products
Gulf Oil Company
Atlantic-Richfield Company
Shell Oil Company
Exxon Production Research Company
Boston Museum of Science
Union Carbide Corporation
Doyon, Ltd.
Calista Corporation
Alaska Travel Publications, Inc.
INEXCO Mining Company
R & M Engineering & Geological Consultants
AMAX Coal Company
Enplan Corporation
BP-Alaska Ltd.
Bendix Field Engineering Corp.
Imperial Oil Co.
Dames & Moore
California Institute of Technology/Jet Propulsion Laboratory
Chugach Native Corp.
Environmental Research & Technology Inc.
Univ. Washington/Remote Sensing Applications Lab.
R. W. Voss & Associates
Placid Oil Company

JAMES A. MACK
DISTRICT 27

STATE CAPITOL · SENATE WING
PHOENIX, ARIZONA 85007

REPUBLICAN WHIP

COMMITTEES
AGRICULTURE, COMMERCE & LABOR
NATURAL RESOURCES

II-C(3-1)

Arizona State Senate

Phoenix, Arizona

July 6, 1976

Dr. James C. Fletcher
NASA Headquarters
Code A
Washington, D.C. 20546

ORIGINAL PAGE IS
OF POOR QUALITY

Dear Dr. Fletcher:

After looking into the complete program of Satellite Remote Sensing, it becomes apparent its capabilities are much more than most legislators, who are not generally informed of the program potential, realize or seem to care about.

I sincerely hope you will do all possible to keep this valuable resource available to us at a state level. Please let me know if there is anything I may do to help you in this important effort.

Having been involved in natural resources areas in the State of Arizona where the NASA Satellite Remote Sensing program was a pilot project, I know from first-hand knowledge of state agencies who have utilized the information as to the inestimable value of the services and performance that has been delivered to us here in Arizona.

I feel sure that as knowledge of the program and its potential becomes more widespread, more uses will be found for its capabilities.

Sincerely,

J. Mack

James A. Mack
State Senator

Action Copy to E
Info Copy to A, AD, AA, ADA, B
A: 37024
Rec'd in NASA 7-13-76
Suspense Date 7-27-76
Prepare Reply for Signature of E

Action Copy to EK
Info Copy to E, ED, ED-M, ER

Rec'd in Code E 7/14/76
Control Number E-418
Suspense date 7/21/76
Prepare Reply for Signature of E

C. (4)
CALIFORNIA

STATE OF CALIFORNIA—RESOURCES AGENCY EDMUND G BROWN JR, Governor

DEPARTMENT OF WATER RESOURCES
BOX 388
SACRAMENTO
95802
(916) 445-9248

Action Copy to EK
Info Copy to ED
ED-M
ER

Rec'd in Code E 7/19
Control Number E-428
Suspense Date 7/26
Prepare Reply for Signature of E

JUL 12 1976

Action Copy to E
Info Copy to A, ADL
AA
ADA
B
A-27160

Rec'd in NASA 7-15-76
Suspense Date 7-29-76
Prepare Reply for Signature of E

Honorable James C. Fletcher
Administrator
National Aeronautics and
Space Administration
400 Maryland Avenue, SW
Washington, DC 20546

Dear Dr. Fletcher:

The Department of Water Resources is greatly interested in participating in the National Aeronautics and Space Administration's (NASA) Water Management and Control Project, Application Systems Verification Test. We have been very impressed with the progress made by the Space Sciences Laboratory (University of California at Berkeley) on the related NASA funded project titled "Inventory of Irrigated Lands for Selected Counties Within the State of California". Projects such as this, which focus on specific user needs, must be undertaken to evaluate the operational utility of LANDSAT imagery.

It is very important that the Department of Water Resources participate in the examination of opportunities for utilizing satellite imagery for land use information collection. We have a continuing program of land use data collection, currently funded at about $350,000 per year. We are interested in any new techniques and procedures which may increase the effectiveness of our program. In addition to meeting our needs, the data produced are used by many other governmental agencies--local, state, and federal.

save water
DWR

JUL 12 1976

We hope that the Water Management and Control Project, Application Systems Verification Test, is approved and that we will be allowed to participate in this test.

Sincerely,

Ronald B. Robie

Ronald B. Robie
Director

cc: Mr. Russell L. Schweickert
User Affairs Office
National Aeronautics and
Space Administration
EK Federal Office Building 10B-Room B236
400 Maryland Avenue, SW
Washington, DC 20546

Mr. Jerry Deerwester
Ames Research Center
National Aeronautics and
Space Administration
MS 242-4
Moffett Field, CA 94035

STATE OF CALIFORNIA—BUSINESS AND TRANSPORTATION AGENCY EDMUND G BROWN JR, Governo

DEPARTMENT OF TRANSPORTATION
TRICT 7, P.O. BOX 2304, LOS ANGELES 90051

June 28, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
Washington, D.C. 20546

ORIGINAL PAGE IS
OF POOR QUALITY

Dear Dr. Fletcher:

We have been informed by Dr. Nevin Bryant of Jet Propulsion Laboratory on the potential land use data products available from the proposed Thematic Mapper satellites. Our planning process could definitely benefit from the availability of such products. We would encourage the continued work and development of these remote sensing systems.

Sincerely,

D. A. Dove

D. A. DOVE, Chief
Transportation Planning
LARTS Branch

Action Copy to E
Info Copy to A, AD
AA
A-26793 ADA
Rec'd in NASA 7-2-76
Suspense Date 7-19-76
Prepare Reply for
Signature of E

Action Copy to EK
Info Copy to ER
E
ED-M
Rec'd in Code E 7/8
[illegible] E-396
[illegible] 7/16
Prepare Reply for
Signature of E

II-C(5-1)

State Representative
GERARD FRANK
[illegible]890 E. 5th Ave.
Aurora, Colo. 80010

Chairman,
Transportation and
Energy Committee
Member of:
Appropriations Committee
Judiciary Committee

Centennial State

COLORADO
HOUSE OF REPRESENTATIVES
STATE CAPITOL
DENVER, COLORADO 80203

August 20, 1976

Mr. James C. Fletcher
Administrator
N.A.S.A. HQ Code A
Washington, D. C. 20540

Dear Mr. Fletcher:

I understand that you wish an expression of opinion about whether the LANDSAT Follow-on program would be of value to states.

After reviewing the proposed technical capacities of the satellite with individuals in several departments of Colorado's government and with individuals in several regional organizations, I conclude that the follow-on program would be of great value in Colorado. I have appended a list of uses for which the data gathered by LANDSAT Follow-on would be immediately useful to many ongoing programs, and would be of perhaps even greater value to several programs likely to be inaugurated by the legislature in the near future.

My investigation also leads me to conclude that a major impediment to effective use of remotely sensed data is a lack of understanding on the part of the operating personnel in our civil service about the availability of these data and the ease with which they may be used. I respectfully urge that the program include a greater commitment to communicating the capabilities of the program to potential users than exists in the present LANDSAT program.

Very truly yours,

Gerard V. Frank

Gerard V. Frank

GVF/lr

cc Governor Richard Lamm
Mr. Phillip Schmuck, Division of Planning
Mr. Lou Campbell, State Cartographer
Mr. Tom Nussbaum, Governor's Office
Ms. Sally Bay, National Conference of State Legislatures
File, Legislative Council

enc
1. page, List as stated above.

Action Copy to E
Info Copy to A, H.D., AA, AD, AC, B
A-28244
Rec'd in NASA 8-30
Suspense Date 9-14
Prepare Reply for Signature of S

ORIGINAL PAGE IS
OF POOR QUALITY

State Level

- supervising mined land reclamation (*)
- confirming siting for energy facilities (**)
- inventory of noxious weeds (*)
- predicting revenues based on more precise crop forecasts (*)
- determining sites for one or two major airports and several minor ones (**)
- data for a state level recreational resources plan (*)
- Identification of agricultural land to be afforded special preservation (**)
- inventory of water resources (*)

Regional (multi-county) level

- all of the uses at the state level, scaled appropriately for regional use (**)
- water quality management, particularly of non-point sources (*)
- better collection of empirical data on flooding (if technically feasible) (*)
- collection of regional scale data on the spread of of various types of pollutants from Denver in order to establish an appropriate ground network (*)
- changes in the extent of urbanization (*)

(*) indicates data required by an existing state or regional program

(**) indicates data needed for a program which has passed at least one chamber of the legislature on two occasions in the past four years.

STATE OF FLORIDA

OFFICE OF GOVERNOR REUBIN O'D. ASKEW

July 6, 1976

Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration
Room 7137, Federal Office Building 6
400 Maryland Avenue Southwest
Washington, D.C. 20546

Dear Dr. Fletcher:

It is a pleasure to advise you of our support for the proposed NASA LANDSAT Program as outlined in your meeting with representatives of interested State agencies on June 2, 1976. If it is possible and consistent with national security precautions, we would support and welcome even higher resolution imagery than is currently proposed.

Attached are comments from various State agencies and several interested university professors responding to the Division of State Planning and stating the agencies' perspectives of LANDSAT and its possible use in different governmental programs.

As Chairman of the Southern Growth Policies Board, I have also enclosed a copy of the Board's resolution in support of this program.

With kind regards,

Sincerely,

Governor

ROA/frs

Enclosures

cc: Mr. Russell L. Schweichart
Assistant Administrator, NASA

ORIGINAL PAGE IS OF POOR QUALITY

RESOLUTION

IN SUPPORT OF

THE LANDSAT FOLLOW-ON PROGRAM

WHEREAS, the demand for and utilization of natural resources is constantly increasing due to an increased population and an increased rate of consumption per individual, and

WHEREAS, the supply and quality of natural resources are finite, and

WHEREAS, the region and the states represented by the SGPB are experiencing significant and rapid population growth and development, and

WHEREAS, the SGPB has taken a strong interest in the proper management of the South's natural resources and has identified specific recommendations directed toward optimizing the regional growth and achieving the desired balance between economic development and environmental quality, and

WHEREAS, there is a keen awareness by the SGPB of the significance, increasing complexity and lasting impact of decisions which are made relative to the use of natural resources in the South, and

WHEREAS, the SGPB recognizes that an essential requirement for improved decision-making and intelligent resource management is an effective information base, and

WHEREAS, the SGPB strongly believes, on the basis of previous experience, that the type of information obtained by remote sensing technology from the Landsat program is extremely useful to the Southern states in providing the information necessary for the analyses of their natural resources, and

WHEREAS, the SGPB member states have indicated a strong interest and intention to use Landsat data to assist their resource management programs in the future and has approved a resolution supporting the expansion of the technolgy transfer capacity at NASA's Earth Resources Laboratory in Slidell, Louisiana.

THEREFORE, the Executive Committee of the SGPB hereby strongly endorses the continuation and improvement of the NASA Landsat system through the implementation of the Landsat follow-on program and associated user assistance and technology transfer efforts as a key step in the provision of improved and cost effective remotely sensed information required by the states to effectively manage their natural resources.

The resolution by the SGPB in support of the Landsat follow-on program is based on the knowledge and experience of state, regional and local resource managers in the application of Landsat data to earth resource programs in the South. The applications of present Landsat data have proven extremely useful and provide a basis upon which to expect significant socio-economic benefits to be accrued to the states of the South as a result of the continued availability of Landsat data.

Governor Reubin O'D. Askew
Chairman, Southern Growth Policies Board

William L. Bowden
Executive Director and Secretary
Southern Growth Policies Board

Florida Resources and
Environmental Analysis
Center

The Florida State University
Tallahassee, Florida 32306

June 8, 1976

Walter Kolb
Division of State Planning
IBM Building
Tallahassee, Fla 32301

Dear Walt.

This letter is in regard to the meeting we had with Reid Barnett, Project Manager of the Science and Applications Project Office of NASA at Kennedy Space Center last week. While FREAC does not have any specific project going right now within which we could use the landset photography, I do believe that it would be desirable to develop with your office and with NASA a continuing methological project to update the landuse information that we are getting.

This summer I am adding to our staff a remote sensing specialist and it is my hope that we would begin then to utilize the remote sensing imagery with the high altitude photography to develop the natural resources inventory the state has needed for so long. May I interject at this point that I feel that within any program that we would be interested, the high altitude photography will be very important and it bothered me that Mr. Barnett indicated that this activity would be curtailed.

From our meeting the other day there was an indication that many people did not have an idea of what landset was all about and what it could be used for. It seems to me that it might be reasonable for the State of Florida to develop a "practical applications of remote sensing" seminar or course or information system which the various state, regional, and local agencies could attend to find out just what they could use from this material. It seems to me that such a seminar could include a great deal of public relations work between the Division of State Planning and the local agencies. These are just somewhat idle thoughts, but if you feel that FREAC could be of any assistance in developing such a seminar or educational program we would be more than happy to cooperate with you in, through our continuing education center, set up for Tallahassee or other parts of the state.

If I may be of any further service to you do not hesitate to call on me.

Sincerely,

Ed

Edward A. Fernald
Director

cc: Reed Barnett

II-C(6-3)

ROBERT L. SHEVIN
Attorney General

STATE OF FLORIDA
DEPARTMENT OF LEGAL AFFAIRS
OFFICE OF THE ATTORNEY GENERAL
THE CAPITOL
TALLAHASSEE, FLORIDA 32304

Civil Division
725 South Calhoun Street
Bloxham Building
Tallahassee, Florida 32304

June 18, 1976

Mr. R. G. Whittle, Jr., Director
Division of State Planning
660 Apalachee Parkway, IBM Building
Tallahassee, Florida 32304

Dear Mr. Whittle:

Attorney General Shevin has asked me to respond on his behalf to your letter of June 7, 1976 concerning the proposed second phase of the LANDSAT Satellite Program. The Department of Legal Affairs is in favor of the provision for a second generation satellite able to perform as described in your letter. Photographs from former satellites have already proven useful in at least one of the Department of Legal Affairs' suits to protect the natural environment and water supply for the citizens of Florida. In addition to similar use, information gathered by the improved satellite could be used in planning at the state and local levels, through the identification of important resources, as well as human influence on those resources.

Lacking technical expertise among the members of its staff, the Department of Legal Affairs has no suggestions for improvement of the satellite program.

Sincerely,

ROBERT L. SHEVIN
Attorney General

Thomas A. Harris
THOMAS A. HARRIS
Assistant Attorney General

RLS/H/g

ibin O'D. Askew
Governor

A. L. Baker
Executive Director

STATE OF FLORIDA

DEPARTMENT OF BUSINESS REGULATION

OFFICE OF EXECUTIVE DIRECTOR
THE JOHNS BUILDING
TALLAHASSEE

June 10, 1976

Mr. R. G. Whittle, Jr.
State Planning Director
Department of Administration
660 Apalachee Parkway
Tallahassee, Florida 32304

Dear Mr. Whittle:

In response to your letter of June 7 regarding the proposed second phase of the LANDSAT Satellite Program it is difficult for me or anyone in the Department to make meaningful comments because we are not familiar with the proposal nor with the current program.

I have discussed the matter very briefly with Mr. Jon Beazley of the Department of Transportation and it would appear that information gathered under such a program could be useful to our Division of Florida Land Sales and Condominiums in the surveillance of registered subdivisions and perhaps in the detection of unregistered subdivisions. The usefulness of the program would depend upon the timeliness of the output, the availability and manner in which data would be displayed for examination and the extent of detail so displayed.

As an example of possible use, our land sales inspectors must make periodic inspections of subdivisions to determine if construction of roads and drainage is proceeding according to schedule. If visual displays would on the one hand permit identification of the tract and on the other hand show sufficient detail to permit evaluation of construction progress this could be quite useful and probably result in some cost savings to the State. Similarly such information could be used to determine if a subdivision submitted for registration is comprised of land which matches the description contained in the application. The latter would be extremely helpful because such tracts at the outset often are without access roads and it is impossible for the inspector to get into the area to make a comprehensive inspection.

These are some uses that could help our Department. I mention them without attempt to attach cost factors or cost justification and with the understanding that as a federal program, State funds are not involved.

We presently do not feel the program would be of value to our Pari-Mutuel, Hotels and Restaurants, Beverage or General Regulation Divisions.

I hope these vague comments will be useful for your purpose. If further input is desired I would suggest a meeting with some of our land sales people who incidentally will be moving their division offices from Tampa to Tallahassee as of July 1, 1976.

Sincerely,

A. L. Baker
Executive Director

ALB/ab

cc: Mr. Richard C. Booth
Mr. Jon Beazley

II-C (6-5)

Philip F. Ashler
STATE TREASURER
INSURANCE COMMISSIONER
FIRE MARSHAL

Office of Treasurer
Insurance Commissioner
STATE OF FLORIDA
TALLAHASSEE 32304

RECEIVED
JUN 15 1976
DIRECTOR'S OFFICE
DIV. OF STATE PLANNING

June 14, 1976

Mr. R. G. Whittle, Jr.
State Planning Director
Department of Administration
660 Apalachee Parkway
IBM Building
Tallahassee, FL. 32304

Dear Randy:

This will acknowledge receipt by this office of your recent letter regarding the proposed second phase of the LANDSAT Satellite Program.

Although it appears doubtful that this program would directly impact the Department of Insurance or the Division of the Treasury, it could provide invaluable data for geologists and planners which would be of interest to Commissioner Ashler as a member of the Florida Cabinet.

Your letter and any additional information that you believe may be helpful will be retained in our files for future reference.

Sincerely,

Jim

James A. Snyder
Administrative Assistant

JAS/dd

Florida Department of Transportation

Haydon Burns Building, 605 Suwannee Street, Tallahassee, Florida 32304, Telephone (904) 488 8772

REUBIN O'D. ASKEW
GOVERNOR

TOM WEBB, JR.
SECRETARY

June 10, 1976

Mr. R. G. Whittle, Jr., Director
Division of State Planning
Department of Administration
660 Apalachee Parkway - IBM Building
Tallahassee, Florida 32304

Dear Randy:

In response to your letter of the seventh, we have used ERTS/LANDSAT satellite imagery on several occasions and found it beneficial. We expect that our use will be much greater when better quality and faster deliveries are achieved.

Several times false color enlargements were used for orientation at public hearings. Also, we have used it to observe lineaments and faults in the geologic substructure of Florida in our sinkhole detection program; to evaluate possible blockage of water by highways across the Everglades (there was very little); evaluation of the Suwannee River flood limits in 1973; and up-to-date indicators of land use changes.

Our use has been limited solely because the imagery is frequently very poor. Also, the slow delivery after ordering reduces its value. With a higher resolution and faster delivery, we expect frequent use of the Follow-On data.

Very truly yours,

Tom Webb Jr

Tom Webb, Jr.
Secretary of Transportation

TWjr:bs

COLLEGE
OF
ENGINEERING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA 32611
AREA CODE 904 PHONE 392-0933

DEPARTMENT OF CIVIL ENGINEERING

June 11, 1976

Mr. R. G. Whittle, Director
Division of State Planning
Department of Administration
State of Florida
660 Apalachee Parkway
Tallahassee, FL 32304

Dear Mr. Whittle:

N.A.S.A. has chosen the University of Florida to be the southeastern center for research in imagery applications to geotechnical problems. A grant of $100,000 per year beginning July 1, 1976 has been awarded. The Coastal Engineering Laboratory, Department of Civil Engineering, and Department of Geology will be involved during the first year. Later we plan to extend this program to other departments and other state universities. We are now assured of three years of financial support from N.A.S.A with the subsequent per year amount being diminished or increased depending upon our yearly success. We have been directed to specifically apply our efforts toward the solution of problems in cooperation with governmental agencies.

You may be aware that the State of Florida has lagged behind most other states in the utilization of the valuable resources that have been made available by LANDSAT imagery. Multispectral analysis and other sophisticated imagery techniques are of great value in the delineation of geological feature and in characterization of the physical parameters of surficial soils. Both at the University of Florida and the Division of Geology of the Department of Natural Resources, we believe remote sensing to be a most valuable scientific technique in mapping.

We sincerely hope that the administrative agents of our state will realize that we are only now beginning to utilize the resources developed by the N.A.S.A. imagery program. As experience and knowledge is broadened more people will be aware of and utilize remote sensing.

This state is most fortunate in having the General Electric Laboratory at Daytona Beach in which the Image 100 system was developed. This is a computer which was developed for processing, enhancing, and analyzing spectral data transmitted from the satellites.

It is our belief that the proposed second generation LANDSAT Satellite is worthy of our support. This satellite will provide additional bands in the infra-red and an improved resolution of spectral bands which increases the opportunity of computer analysis for identification of terrain parameters. This will provide improved evaluations of hydrologic and geotechnical parameters which will make it possible to more accurately map details.

Sincerely,

H. K. Brooks/db

H. K. Brooks
Professor Geology
and Principal Investigator
of N.A.S.A. Project

Byron Ruth /db

Byron E. Ruth
Associate Professor of Civil Engineerin
and President, Florida Region
American Society of Photogrammetry

BER/db

cc: Mr. Reed Barnett, NASA
Mr. Jon S. Beazley, F.D.O.T.
Dean Morton Smutz, EIES

STATE OF FLORIDA FLORIDA DEPARTMENT OF AGRICULTURE & CONSUMER

DOYLE CONNER COMMISSIONER * THE CAPITOL / TALLAHASSEE 32304

June 14, 1976

RECEIVED
JUN 22 1976

DIRECTOR'S OFFICE
DIV. OF STATE PLANNING

Mr. R. G. Whittle, Jr.
State Planning Director
Department of Administration
Division of State Planning
660 Apalachee Parkway
IBM Building
Tallahassee, Florida 32304

Dear Mr. Whittle:

The NASA proposal to advance satellite photography and to provide remote sensing to State agencies is very interesting and has been investigated by some of my staff. They do not feel that there is sufficient benefit for the Department to support the development of the second phase of the LANDSAT Satellite Program.

The photography provided by the current system is not of sufficient resolution to be of value in detailed county-by-county forestry or agricultural work. An alternative proposal would be to further improve aircraft based photogrammetric technique. Improvements in resolution using aircraft based photography would do more for Agriculture than the larger area coverage obtained from satellite photography.

We understand that Weyerhaeuser Corporation has utilized satellite photography in some of its forest management programs. Perhaps some familiarization with the work that they were able to accomplish would help in convincing state agencies of the value of NASA's proposal.

We are currently able to meet our aerial photogrammetric needs through the excellent facilities which are provided by the Florida Department of Transportation.

With kind regards, I am

Sincerely,

Doyle Conner

Doyle Conner
Commissioner

DC/ga

C (7) GEORGIA

Office of the Governor

Atlanta, Georgia 30334

George Busbee
GOVERNOR

Norman Underwood
EXECUTIVE SECRETARY

April 19, 1976

Dr. James C. Fletcher
Administrator
National Aeronautics and Space
Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

As you may know, the State of Georgia is currently using NASA developed technologies and products, and is in the process of evaluating specific applications of NASA developed technologies in a variety of State data collection and planning programs. Three substantial NASA research and evaluation efforts are underway in the State at the present time. They are:

Remote Sensing and Classification Technology Transfer Evaluation

This study is to evaluate the usefulness of remote sensing and classification capabilities developed by NASA's Earth Resources Laboratory in inventorying Georgia's natural resources and planning for their wise use. If these technologies prove useful and feasible, as they already have been in Georgia's Coastal Zone Management Program, they will be developed as a basic component in the data collection and mapping programs for the State.

Land Features Classification Research

The Earth Resources Office of the Marshall Flight Center is supporting remote sensing and land characteristics classification research currently in progress at the Georgia Institute of Technology. This research effort is intended to develop land use classification techniques and land development change detection techniques for use in urban and rural areas in Georgia.

Salt Water and Wetlands Identification in Coastal Georgia

The Georgia Department of Natural Resources has used satellite collected data experimentally to detect and identify saltwater and freshwater species of plant life to determine the limits of the tidal waters in Coastal Georgia. This use of classified imagery has proven beneficial to identifying the areas of concern in the Coastal Zone Management Program.

Other organizations in Georgia, such as the Atlanta Regional Commission and the Georgia Mountains Area Planning and Development Commission are experimenting with using NASA developed technologies to collect vegetative cover, soil wetness, land use and land use change data.

I would like to commend your office for the excellent professional assistance provided to Georgia in these projects. I also encourage you to continue in your efforts to promote the development and use of these technologies for State and local governments and to continue in your efforts to develop and refine the state of the art.

Sincerely,

George Busbee

George Busbee

GB:abc

cc: Mr. Alex Tayahov
Dr. C. T. N. Paludan
Dr. Wayne Mooneyhan

Remote Sensing Activities Involving the State of Georgia

Work with the State

- o Georgia Natural Resources Information System Technology Survey

  Earth Resources Laboratory will transfer a resources information system to the State of Georgia during FY77.

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- o Peach Tree Decline

  Marshall Space Flight Center in cooperation with Georgia Institute of Technology

- o Landsat and Skylab Data Uses

  Sam Pickering, Chief Geologist, Geological Survey, Department of Natural Resources, Georgia

  -- Successfully used both Landsat and Skylab data in ground water prospecting. Ref. "Practical Applications of Landsat Data for Earth Resources Survey," May 1975, Page 35.

  -- Same individual reported in Goddard Space Flight Center Symposium, December 1973, G-21, Page 857, that Landsat Data useful for:

     (1) Major tectonic boundaries
     (2) Lithologic contacts
     (3) Foliation trends
     (4) Topographic lineaments
     (5) Faults

Work within the State

- o Landsat I - Forest Inventory performed by USFS on Federal Lands
- o Landsat II - Forest Inventory being performed by USFS (Aldrich)
- o St. Regis has proposed a project to use Landsat data and supplemental information for inventory of company-owned or controlled land in Western Georgia.

Department of Natural Resources

270 WASHINGTON ST., S.W.
ATLANTA, GEORGIA 30334
(404) 656-3500

Joe D. Tanner
COMMISSIONER

Action Copy to EK
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May 25, 1976

Rec'd in Code E 6/8
Control Number E-313
Suspense Date 6/15/77
Prepare Reply for Signature of A

Action Copy to E
Info Copy to A, AR
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A 26101

Rec'd in NASA 6-7-76
Suspense Date 6-21-76
Prepare Reply for Signature of A

Dr. James C. Fletcher
Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

It is my understanding a decision regarding the LANDSAT follow-on will soon be made. In this event, I am writing to express the Georgia Department of Natural Resources' interest in the follow-on program.

In recent years there has been a dramatic increase in the number of natural resource programs. As a result of this increase, we are moving toward a more comprehensive, and often complex, approach requiring more timely and accurate data. It is our belief that the existing and proposed satellite systems have a definite role to play in Georgia's natural resource programs.

Until now, there has never before been an economically feasible method to acquire a data base that adequately describes existing site conditions, and the changes that are taking place. Presently, most State programs incorporate the use of manual techniques to collect and analyze such descriptive data. Although these manual techniques are simple and straightforward, they have serious limitations in that they are often not timely, comprehensive, and area specific. Manual techniques are often costly and difficult to update plus awkward to store and manipulate in large quantities.

In an attempt to improve upon the above situation, the State of Georgia has entered into an agreement with NASA to evaluate and transfer automatic classification techniques utilizing LANDSAT data. The intent of this Research Technology Operating Plan (RTOP) will be to successfully demonstrate technical LANDSAT capabilities which will produce results needed for existing programs and management decisions. To date, Department of Natural Resources' personnel have been preparing project proposals which identify specific requirements of existing and proposed management programs. These requirements include a discussion of potential data sources to satisfy program requirements, a description of the methodology to be used and products to be obtained, and benefits to be accrued. These project proposals will then be evaluated against the LANDSAT digital products. A few programs within DNR which should benefit from successful LANDSAT applications are the Environmental Protection Division's (EPD) areawide waste treatment management program (Sec. 208) under P.L. 92-500, EPD's Solid Waste Management Program and Land Reclamation Programs, the Game and Fish Division's Pittman-Robertson and other wildlife

management programs, plus the Departments land acquisition and comprehensive review process. These programs should benefit greatly from LANDSAT digital data since it will provide site-specific information on an iterative basis. The result should be more responsive programs with a dollar savings to the user.

Of comparative interest are the 1" = 1 mile manually produced vegetation maps prepared for each of Georgia's 159 counties. The cost of this project was approximately \$30,000, or about 50¢ per square mile, which did not include administrative costs to DNR. Although this information has proven quite useful, there appear to be liabilities of the manually produced maps when compared to the LANDSAT digital capabilities: first, the minimum mapping unit of the manually produced maps is 50-100 acres as compared to 1.1 acre for the digital satellite information; second, satellite data is less expensive to produce once a processing center has been established; and third, the satellite information is less expensive to update since it has iterative capabilities. These satellite capabilities are important considerations which should prove to be of great benefit to natural resource programs.

A recent project which came through the environmental review process which would have had application to automatic classification techniques was a 60,000 acre small watershed project (P. L. 566) for the purposes of watershed protection and flood prevention. This coastal watershed contains about 242,000 acres containing three primary vegetation habitats: lowland hardwoods, mixed hardwoods with pine and pine flatwoods. The area of the proposed project is a mixture of hardwoods and pines and lowland hardwoods. If an automatic classification system were operational it would have provided the following spatial data and statistical acreage information which would have been an indication toward the location of drainage ways containing riverswamp hardwoods, areas inundated by water at various times of year, an indication of wildlife habitats, and a determination of the salt and fresh water interfaces as defined by salt emergent vegetation. This data would have enabled us to make a better quantitative determination of the project's effects as required by the National Environmental Policy Act of 1969. This system should also allow us to monitor the impacts of increased peak flows on the estuary and reduced low flow conditions on the river swamps and tributaries.

With regard to the acquisition and leasing of lands for wildlife management the following considerations are offered. Accurate and current land-cover information could greatly facilitate the identification of suitable lands for possible acquisition or lease. The types of data required includes vegetation associations, an indication of understory conditions as inferred from vegetation crown density, the proximity of any potential wildlife management areas to developed lands, and the location of surface water bodies. If this data can be obtained on a timely and cost-effective basis, then our management and acquisition program could be substantially improved. This would be particularly true if the follow-on satellites have a 30 meter resolution in the visible bands allowing even better vegetation separation and boundary determinations.

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The Department of Natural Resources and the Army Corps of Engineers, Savannah District Office will be evaluating the potential of LANDSAT digital data to assist in determining the approximate areas of jurisdiction under Section 404 of P.L. 92-500. The projects goal will be to determine if automatic classification of digital satellite data will provide necessary land cover data at a cost-effective rate to satisfy the requirements of the Corps 404 program. Further, it is anticipated that change detection techniques can be employed to assist in determining the locations of authorized versus unauthorized land disturbing activities.

Regarding Georgia's Section 208 program, LANDSAT digital processing will be evaluated for its ability to locate land-cover information and statistical acreage data within water quality management units (WQMU). Activities such as agriculture, silviculture, mined areas and urban construction are to be evaluated in an effort to determine the potential of a WQMU for non-point source pollution. Presently we feel confident that the twelve categories to be processed for this program will be adequately handled by the present satellite provided normal functioning continues and operational status is achieved. A major advantage of the follow-on satellites for water resource programs will be the water penetration capabilities of the blue band to detect sediment and nutrients in surface water bodies and the heat sensitive capabilities of the thermal infrared bands.

In the Environmental Protection Division's Solid Waste Management Program, present efforts are focussing on land cover categories to assist in determining potential areas which may fit the partial criteria for sanitary land fill site selection. By determining these potential areas, local and state resources will be more efficiently used while producing more responsive results.

The above comments are offered as a briefing of activities currently underway in the Department of Natural Resources to use LANDSAT digital data. Although the actual amount of processing has to date been minimal, a great deal of effort has gone into the evaluation of DNR programs and management criteria which could benefit from an operational processing capability. In an attempt to insure this capability, $40,000 has been spent by the Georgia Institute of Technology on hardware with an additional $23,000 expected shortly.

The equipment will be operated by Georgia Institute of Technology personnel who are experts in the automatic approaches to remote sensing. They will be responsible for keeping abreast with the latest techniques while providing the interface between the equipment and the State's natural resource program managers. It can be anticipated that upon favorable results of a demonstration project to be conducted by August of 1976, that several programs receiving State and federal dollars will choose to process regional or statewide LANDSAT data.

We in Georgia are beginning to use the LANDSAT data in a routine manner, but have also recognized that the system is <u>not</u> classified as operational. Therefore, significant commitments to training, technology, and equipment could prove risky. If our demonstration results prove as positive as we expect, DNR and other state agencies would have a tremendous need for an operational satellite capability.

It is also very important to recognize that data must be available to users at a high resolution, with a quick turnaround time, at a low cost, and in a "rectified form". Although there is a great deal of interest in greater resolution and more rapid data delivery, it must be recognized that trade-off exists between the two, with cost the ultimate limiting factor. tified data referenced to the ground and to a nominal scene with sufficient accuracy should be available in volume to greatly increase the usefulness and affordability of the information. Rectification is the main requirement to make it possible to geographically reference information extracted from remotely-sensed data to other physical and socio-economic information.

Further, it is imperative that users get involved in developing future programs. Federal agencies should have a structured effort to this end. State and local governments, the primary users, sharing the responsibility of defining their needs and expressing them to the federal government.

In conclusion, we appreciate this opportunity to express our point of view on the need to expand and improve federal space programs and technology of benefit to the states---particularly a program beyond the financial capability of the individual states. I hope these comments are of some value to you and, if I can be of further assistance, do not hesitate to call on me.

Sincerely,

Joe D. Tanner
Commissioner

JDT/bre

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C. (8) HAWAII

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EXECUTIVE CHAMBERS

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Suspense Date 7-21-76
Prepare Reply for
Signature of A

GEORGE R ARIYOSHI
GOVERNOR

June 14, 1976

Dr. James Fletcher
Administrator
National Aeronautics and Space
Administration
Washington, D.C. 20546

Dear Dr. Fletcher:

This letter is to inform you that the State of Hawaii is very much interested in the utilization and improvement of your Earth Resources Satellite Program.

In view of our geographic isolation and limited land area, we must plan very carefully for the optimum use of our precious land and water resources. In this regard, our State governmental agencies have been following closely developments in satellite image technology and, with the help of your Ames Research Center, have begun to apply this technology to our on-going State planning process.

Our limited experience indicates that satellite data could be a very important source of information in fulfilling our many mandates and responsibilities regarding land use planning, environmental protection, economic development, and coastal zone management. It is essential, however, that the information source, namely the satellites themselves, continue to function effectively and provide us the desired data which will allow us to fully pursue the application of this technology to Hawaii.

We strongly encourage you, therefore, to press for the continuation and enhancement of the Earth Resources Satellite Program. If we can be of any service or assistance in this regard, please feel free to call upon us at any time.

With warm personal regards, I remain,

Yours very truly,

George R. Ariyoshi

George R. Ariyoshi

cc: Dr. H. Mark, Director
Ames Research Center

Mr. K. Nishioka
Ames Research Center

GEORGE R. ARIYOSHI
Governor

HIDETO KONO
Director

FRANK SKRIVANEK
Deputy Director

DEPARTMENT OF PLANNING
AND ECONOMIC DEVELOPMENT

Kamamalu Building, 250 South King St., Honolulu, Hawaii • Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

Ref. No. 1373

June 14, 1976

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Rec'd in NASA 7-6-76
Suspense Date 7-20-76
Prepare Reply for
Signature of E

Dr. James Fletcher
Administrator
National Aeronautics and Space
Administration
Washington, D.C. 20546

Dear Dr. Fletcher:

This letter is to inform you of our strong and continuing interest in your Earth Resources Satellite Program and, in particular, your LANDSAT Follow-on Satellite project.

While we are only now beginning to appreciate the potential of space imagery in fulfilling our programmatic data needs, we believe that the improved resolution of the LANDSAT Follow-on Satellite will broaden considerably the applicability of LANDSAT data to Hawaii. Not only will this type of remote sensing data enhance our monitoring capabilities in terms of land use changes and impacts, but it will also serve to reduce required on-site inspections as well as allow for more effective utilization of staff and improved administration.

The acquisition of this type of data on a regular basis will provide the essential historic and current information needed to ascertain how the limited land area of our State can best be utilized. This is of utmost importance in light of our mandate to advise our State decision-makers on the optimum use of our natural resource base. We believe that the data provided by the NASA Earth Resources Satellites will both assist us in evaluating the effects of past decisions as well as provide us with a sound, technical basis to evaluate alternatives and make better and more intelligent decisions regarding Hawaii's future.

As a basis for committing resources for the development of new techniques and methodologies, however, it is essential that we have some reasonable assurance regarding continued data availability. In this regard, we urge you to vigorously pursue the continuation and expansion of your Earth Resources Satellite Program in order that we may maximize our opportunities in this most interesting and valuable endeavor.

We very much appreciate your continued interest in our programs and look forward to working with you on matters of mutual concern.

Sincerely,

for HIDETO KONO

cc: Dr. H. Mark
Ames Research Center

Mr. K. Nishioka
Ames Research Center

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GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

CHRISTOPHER COBB, CHAIRM
BOARD OF LAND & NATURAL RESOU

EDGAR A. HAMASU
DEPUTY TO THE CHAIRMAN

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

DIVISIONS:
CONVEYANCES
FISH AND GAME
FORESTRY
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMEN

June 2, 1976

Dr. James Fletcher, Administrator
National Aeronautics and Space
Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

Members of my department are, more and more, becoming aware of the great potential your Landsat programs have for Hawaii. Aspects of satellite remote sensing are presently being examined for their possible applications to epidemic forest decline studies. Further, we are intrigued as to the satellite's capabilities in vegetation and land use determinations, water and mineral resource studies, and its potentials in planning activities.

It has come to my attention that your agency is considering a program or programs of assistance in Hawaii. We would be appreciative of any help your agency can offer in helping us to learn about and use this new medium, and I ask that you give serious consideration to any proposals concerning us.

I thank you and your staff for thinking of Hawaii, and ask that we continue to receive your consideration and support.

Yours truly,

BOARD OF LAND AND NATURAL RESOURCES

C Cobb

CHRISTOPHER COBB
Chairman and Member

cc: Dr. Hans Mark
NASA - Ames Research Center
Mr. Russell L. Schweickart
NASA Headquarters
Mr. William E. Stoney
NASA Headquarters
Dr. Clifford E. Charlesworth
Lyndon B. Johnson Space Center

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Rec'd in NASA
Suspense Date 6-28

C (9) IDAHO

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STATE OF IDAHO

OFFICE OF THE GOVERNOR

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GOVERNOR

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A-26052

Rec'd in NASA

Suspense Date
Prepare Reply for
Signature of

May 27, 1976

The Honorable Dr. James Fletcher
Administrator
National Aeronautics and Space Administration
Washington, D.C. 20546

Dear Dr. Fletcher:

I understand that NASA has embarded on the planning process preparing for the develcpment of LANDSAT Follow-On systems, which are to be advanced versions of the LANDSAT-B System that we now utilize in our Land Resources Inventory Project. Our expectation is that LANDSAT Follow-On systems will provide a cost effective and timely source of land cover data for use by state natural resources planning and management agencies.

As you know, our motivation for entering into the Land Resources Inventory Demonstration Project in conjunction with NASA and the Geological Survey, stemmed primarily from our continuous need for timely and cost-effective natural resource information. The conventional methods we now utilize are very costly and require a great deal of time, energy and manpower. With the rapid growth of Idaho and the need for thoughtful utilization of its resources, we badly require as much highly accurate data as we can obtain.

While the LANDSAT demonstrations in the project are not yet complete, the results reported by the participating agencies are extremely encouraging. Two examples will highlight our belief in the potential utility of LANDSAT Follow-On systems for resource management activities:

1. An inventory of four million acres of irrigated lands along the Snake River would be extremely useful to many organizations and agencies. Existing data is outdated and virtually unusable for current requirements. It would appear that the cost and time

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involved in a conventional survey would rule out a complete update. However, the staff of the Department of Water Resources believe that a survey based on LANDSAT data could be performed in a timely and cost-effective manner. At least, those are the indications demonstrated through the project to date.

A recent inventory of the vacant lands in the urbanized Boise area, conducted by utilizing conventional survey methods, took one year and $70,000 to complete. Preliminary indications obtained in the Land Resource Inventory Demonstration Project seem to support the idea that the same inventory could be completed with LANDSAT data in a month's time at a substantial cost savings.

We expect to continue to explore the utility of LANDSAT data for land resource planning and management through the Land Resources Inventory Demonstration Project. We have every reason to believe that our urgent needs for timely and cost-effective land cover data can be met using satellite systems, and anticipate that the operational LANDSAT Follow-On systems will be utilized as a major source of data to plan and effectively manage the natural resources of Idaho.

Sincerely,

Cecil D. Andrus

CECIL D. ANDRUS
GOVERNOR

CDA:hcb

House of Representatives
STATE OF IOWA
STATE HOUSE
Des Moines, Iowa 50319

Action Copy to EK
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E
ED-M

Rec'd 7/12
Control No. E-408
Suspense Date 7/19
Prepare Reply for
Signature of E

July 2, 1976

Dr. James C. Fletcher
NASA Headquarters
Code A
Washington D.C. 20546

Dear Dr. Fletcher:

As a member of the NCSL Remote Sensing Task Force, I was asked to convey my opinion as to the need for the LANDSAT FOLLOW-ON Program. I am a member of the Iowa Legislature and a farmer by profession. The LANDSAT FOLLOW-ON Program, particularly with the improved imagery, has a wide variety of uses, some of which border on necessity.

One time imagery is essential for the assessment and evaluation of almost all natural resource programs. Good programs depend on current information. The advantage of LANDSAT is the frequent update of information that can be utilized in an analytical manner to predict the meaning of changes in the ground cover.

As an Iowa farmer the most important aspect is the eventual potential of predicting world food production with some degree of accuracy. As the data base increases and the analysis improves,production estimates during the growing season would be very helpful.

On July 1, 1976 the price of corn in central Iowa increased as much as $.11/bushel and soybeans as much as $.30/bushel. An AP story in the Des Moines Register stated:

> "A big buying factor was an unconfirmed rumor that Russia had bought about one million tons of soybeans. It was also rumored that Russia had bought feed grains from the United States."

Iowa raises approximately one billion bushels of corn and two hundred million bushels of soybeans each year. Yesterday's price increase would mean one hundred seventy million dollars to Iowa farmers if applied to one year's crop. The impact nationally is proportionately greater.

The importance of farm exports in our favorable balance of trade as well as the impact of price fluctuations on the ultimate cost of food makes the market system important to all citizens.

The argument is not that better information will always mean higher prices. It will not. The argument is that more accurate and current information will allow for better decisions at all levels.

Crop production estimates in this country are inadequate. Early season estimates with periodic updates tend to lag far behind what is actually going on. Information from other countries is often little more than "seat of the pants" judgments about what is happening.

With better information on world food supplies and prospective crops, farmers can make better decisions on planting, harvesting and marketing. The planting season when crop plans can still be changed begins in this country as the harvest season begins in the southern hemisphere.

A private firm or a foreign country with a more accurate estimate of grain supplies, even if it pertains primarily to their own holdings, not only have an advantage in the grain market, they are in a position to potentially exploit the American farmer and the public in general. Russia's activity in our grain markets in the past few years has been a classic example. More accurate assessment of Russian grain supplies would be exceptionally useful in determing US export policy.

The total result from LANDSAT FOLLOW-ON will not be immediate although accurate acreage information would be a major achievement. Changes in the imagery during the first growing season will not be particularly meaningful the first season but will improve with each year. Ground proofing of detected variations and the correlation of those variations with yields will continually improve the accuracv.

Time is important. The data base must be developed to provide accuracy. Each growing season is unique in any particular area so a delay in the program means that portion of the data base is lost forever.

World food supplies are marginal. Consideration may have to be given in the near future for management of surpluses in good years to avoid wild fluctuations between devastatingly low prices and subsequent high prices with widespread famine. Any attempt at world food supply management would be futile without an accurate information system.

Given this very fundamental need for the LANDSAT FOLLOW-ON Program, there are many other beneficial uses for the data. Nearly all state agencies involved in natural resource areas can benefit from the program through lower cost imagery, more current imagery or obtaining information that otherwise would be unavailable.

The program at this point has just begun to demonstrate the potential uses for this program. I believe any delay in its future development would be a drastic mistake.

Sincerely,

Andrew Varley

Andrew Varley
State Representative

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AV:ei
CC Delegate J. Hugh Nichols
Ms. Sally Bay
Senator James A. Mack, Vice-Chairman

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Rec'd in NASA 7-7-76
Suspense Date 7-21-76
Prepare Reply for
Signature of E

State of Louisiana
EXECUTIVE DEPARTMENT
Baton Rouge

EDWIN EDWARDS
GOVERNOR

June 30, 1976

Mr. David W. Johnson
Staff Assistant
National Governors' Conference
1150 Seventeenth Street, N.W.
Washington, D. C. 20036

Dear Mr. Johnson:

Recently I received a draft resolution supporting the Landsat Follow-On Program from Governor Salmon. Per Governor Salmon's request, I am forwarding my comments concerning the draft resolution.

We are interested in the proposed improvements of the Landsat Follow-On System. Presently, we maintain computerized land use information as part of Louisiana's Comprehensive Planning Information System. The land use information is delineated from high altitude color infrared photography to the second level of the U. S. Geological Survey classification system. To date, no one has been able to duplicate all second level land use classification utilizing only Landsat information. Should the increased resolution of the Landsat Follow-On Systems enable second level land use delineations to be performed at an equivalent or reduced cost to that of conventional high altitude aerial photography, we would be interested in arrangements to receive the Landsat information.

We are also interested in the possibility of using present and future Landsat satellites for land use change detection. We are aware of federal agency efforts to investigate these possibilities and will be interested in the outcome of the research.

Our own experience with the use of Landsat imagery to delineate flooded areas has convinced state personnel that Landsat imagery is a useful tool for quick evaluation of flood disasters. However, the proposed ten-day delivery schedule may limit the use of Landsat imagery for operational uses.

Of particular concern to our natural resources agencies is the transfer of the Landsat technology to our personnel. It is hopeful that regional technical assistance centers will be

maintained and that these centers will offer short course instruction (three or four days at one time) and on the job training for our state personnel.

Accordingly, we support the implementation of the proposed Landsat Follow-On System.

Sincerely,

Edwin Edwards

EDWIN EDWARDS

EE:bsa

c: Honorable Thomas P. Salmon
Governor, State of Vermont
State House
Montpelier, Vermont 05602

State of Louisiana

EXECUTIVE DEPARTMENT

Baton Rouge

EDWIN EDWARDS
GOVERNOR

April 14, 1976

Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration
Washington, D.C. 20546

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Dear Dr. Fletcher:

NASA has proposed a program which we feel to be of great importance to the technical communities of this nation and state. I am referring to the LANDSAT Follow-On System, and heartily endorse the operation of this system.

We have had a most beneficial relationship with NASA through the Earth Resources Laboratory, Slidell, Louisiana. Many problems in the areas of resource management, wetland surveys, water resource observations, and emergency information have been provided by ERL.

During the recent floods (1973-1975) we were most fortunate to have access to LANDSAT data. Quick decisions are necessary and they must be based on reliable information. We are now entering a period of extreme importance relative to the management of our natural resources. Strip mining operations for recovering lignite will be initiated in the near future. We are anticipating environmental problems and the need for data such as that available from LANDSAT is required in solving such problems.

The Office of State Planning, Department of Public Works, Louisiana Department of Highways (now undertaking ecological studies of the impact of landfills in the wetland), and the Department of Conservation are only a few of the state agencies who have used LANDSAT data. We are looking forward to a continuation of our relationship with NASA, and intend to adopt the LANDSAT-1 land classification system in one of these state agencies this year. ERL will also participate with several agencies in monitoring the coastal environment which will be impacted by development of the off-shore oil terminals. The resolution, geometric correction function, and the increased number of data channels will give more accurate data relative to the coastal zone environment. We are especially interested in the rate of land loss in the delta zone; recent projections reveal that as many as 20 ms.^{2} yr. is being lost. These losses will effect the location of oyster leases, trapping leases, and other resource recovery programs.

The LSU Division of Engineering Research, and the Center for Wetlands Research, in cooperation with the State Division of Administration will commit professional people to the transfer of NASA technology to state agencies during the next year. I refer primarily to the LANDSAT-1 system.

Dr. James C. Fletcher, Administrator
Page 2
April 14, 1976

Please accept our endorsement of the system and if there is any way we can be of assistance in assuring the successful launching of this project let us know.

Sincerely yours,

CAWhitehurst

CHARLES A. WHITEHURST, PhD
SCIENCE ADVISOR TO THE GOVERNOR

kb

cc: Russell L. Schweickart, Director
User Affairs
Office of Applications
NASA
Washington, D.C. 20546

STATE PLANNING OFFICE
OFFICE OF THE GOVERNOR

EDWIN EDWARDS
GOVERNOR

CHARLES E. ROEMER, II
COMMISSIONER OF
ADMINISTRATION

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Info Copy to ER
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ED N

ORIGINAL PAGE IS OF POOR QUALITY

May 17, 1976

Rec'd in Code E 5/20
Control Number E-26
Suspense Date 5/27
Prepare Reply for Signature of E

Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

We are interested in the proposed improvements of the LANDSAT Follow-on System. Presently, we maintain computerized land use information as part of Louisiana's Comprehensive Planning Information System. The land use information is delineated from high altitude color infrared photography to the second level of the U. S. Geological Survey classification system developed by Dr. Anderson and others. To date, no one has been able to duplicate second level land use classification utilizing only LANDSAT information. Should the increased resolution of the LANDSAT Follow-on Systems enable second level land use delineations to be performed at an equivalent or reduced cost to that of conventional high altitude aerial photography, we would be interested in arrangements to receive the LANDSAT information.

We are also interested in the possibility of using present and future LANDSAT satellites for land use change detection. Arrangements are already underway between the U. S. Geological Survey and the Earth Resources Laboratory of the Lyndon B. Johnson Space Center to investigat this possibility. Since a portion of Louisiana may be chosen as the test site for this demonstration, we are awaiting the inception of the project and our involvement.

Due to excellent service rendered by your staff, we were able to provide Governor Edwards with flood inundation information during the April, 197 flood within four days after the pass of LANDSAT. The information was used operationally by state agencies and to document Louisiana's request for a major disaster declaration in 19 parishes. The key factor in the use of the LANDSAT data was its rapid availability made possible by your staff. Although the data from the LANDSAT Follow-on System will be available to the user in approximately ten days, this may not be suffici in cases of natural disasters. It may be appropriate to identify instan e.g., floods, which warrant more timely delivery and establish policies for such requests.

TRICK W. RYAN
IVE DIRECTOR

PAUL R. MAYER, JR
STANT DIRECTOR

504/389 7011

Accordingly, we support the implementation of the proposed LANDSAT Follow-on System. If I can be of further assistance, please advise me accordingly.

Sincerely,

PATRICK W. RYAN
Executive Director

PWR/kc

cc: Governor Edwin Edwards
Louisiana Congressional Delegation
Dr. James R. Anderson
Mr. Charles E. Roemer, II, Commissioner of Administration, Baton Rouge
Mr. Wayne Mooneyhan, Earth Resources Laboratory
Mr. Blaine Liner, Southern Growth Policies Board
Dr. Charles A. Whitehurst, Science Advisor to Governor Edwards

Action Copy to E
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A-25811

Rec'd in NASA 5-19-76

Suspense Date 6-4-76
Prepare Reply for Signature of E

STATE OF LOUISIANA
BOARD OF COMMISSIONERS
OFFSHORE TERMINAL AUTHORITY

1130 International Trade Mart
New Orleans, Louisiana 70130
Telephone 504-527 5016

Action Copy to ES
Info Copy to ER
EP
ER-4

May 7, 1976

Rec'd in Code E 5/13
Control Number
Suspense Date
Prepare Reply for
signature of

Dr. James C. Fletcher
Administrator
NASA
Washington, D.C. 20546

ORIGINAL PAGE IS OF POOR QUALITY

Dear Dr. Fletcher:

I am writing in support of the implementation of the proposed LANDSAT Follow-on System. The capabilities of this system would be extremely valuable to numerous public agencies and private interests in Louisiana, especially in the areas of coastal zone management and deepwater port development. The improvements of the proposed system over LANDSAT-1, particularly increased resolution and timely data transmittal, will not only be useful to our agency, but may be crucial to whether LANDSAT data are suitable for our needs.

The Offshore Terminal Authority was created by the Louisiana Legislature to guide deepwater port development in the State. Assurance of environmental protection is the most important part of this mandate. With the expected development of a Louisiana deepwater port by private interests (LOOP Inc., a consortum of oil and transmission companies), the role of the Authority will largely be that of licensing and regulatory agent of the State. One of the major functions of the Authority within this role will be the conducting of an environmental monitoring program, to detect possible environmental impacts of the deepwater port or its onshore facilities. Remote sensing techniques could be an important source of data to the total monitoring program.

As evidence of our interest in remote sensing, the Authority, in conjunction with NASA, has taken the first steps to utilize LANDSAT remote sensing data in monitoring construction and operation of the Louisiana deepwater port and its related onshore facilities. A proposal has been submitted to NASA management by

the Earth Resources Laboratory of the Lyndon B. Johnson Space Center for a three year demonstration and implementation project aimed at utilizing satellite capabilities in our monitoring program. These satellite capabilities include near-real time data collection and dissemination from ground emplaced sensors, as well land cover classification and water surface temperature and salinity measurement from LANDSAT data. Approval of the project proposal by NASA is expected by May 30, with start of the project in October, 1976. The Offshore Terminal Authority is in the process of obtaining the approvals necessary for our participation.

One of the purposes of the proposed project is to demonstrate the usability of LANDSAT spectral data in determining land cover types and changes in land cover that may be caused by pipeline construction and operation (salt water intrusion, sheet flow interruption, subsidence, turbidity, erosion, etc.), or by operation of offshore and onshore facilities--oil and other possible pollutant discharges. Remote sensing capabilities will be valuable because of the wide area that must be monitored and the relative inaccessibility of much of that area. LANDSAT data should provide basin-wide monitoring at a relatively inexpensive cost, a goal which may be otherwise unobtainable.

Two possible major limitations to our use of LANDSAT-1 data may be resolution and timeliness. It must be confirmed in the demonstration phase of the project that resolution such as the LANDSAT Follow-on System is capable is suitable to our use. We do know at this time that resolution of ¼ acre would be valuable to our program, because of the site-specific nature of our interests. Similarly our need to detect land cover changes quickly, so as to implement corrective action, will require the most timely transmittal of information possible.

In addition to the potential use of LANDSAT data in our comprehensive monitoring program, such data would undoubtedly be valuable in numerous land use mapping and environmentally related projects in Louisiana. Most notable of these would be the developing coastal zone management (Coastal Resources) program being undertaken by the State Planning Office. In addition, we understand Regional Planning Commissions throughout the State are keenly interested in developing accurate land use maps for their areas. The Louisiana Wildlife and Fisheries Commission is presently monitoring the coastal zone to assess the importance of estuarine and marine ecological change on biological productivity, as it may relate to commercial species. These activities will form the basis of future land and water use decisions.

For these reasons, we support the implementation of the LANDSAT Follow-on System, as a necessary and readily available

decision making tool in land use planning and environmental protection.

Very truly yours,

Shepard F. Perrin, Jr.

Shepard F. Perrin, Jr.
Executive Director

SFP/JGC/crc

cc: Mr. Russell L. Schweickart
Dr. Charles A. Whitehurst

Action Copy to E
Info Copy to AD, AA, ADA, X

A-25615

Rec'd in NASA 5-11-76

Suspense Date None
Prepare Reply for —
Signature of

ORIGINAL PAGE IS
OF POOR QUALITY

STATE OF LOUISIANA
DEPARTMENT OF HIGHWAYS
P. O. BOX 44245 CAPITOL STATION
BATON ROUGE, LA. 70804

IN REPLY PLEASE REFER TO
FILE NO.

May 4, 1976

Action Copy to E
Info Copy to A, AD
A25546 AA, ADA
Rec'd in NASA 5-11-76
Suspense Date None
Prepare Reply for
Signature of

Dr. James C. Fletcher
Administrator, NASA
Washington, D.C. 20546

Dear Dr. Fletcher:

Although the Louisiana Department of Highways has not found landsat data applicable to general uses, they have played an important role in a few specific areas. We have used the near infra-red photography in several lawsuits and sensitive land areas to determine the extent of possible water pollution. By ground verification and source identification we have been able to avoid exacerbating an existing problem. The photographs have, in these cases, lead to a review of the proposed drainage structures along highways either planned or being constructed, and, in a few instances, this review has lead to design changes which have improved drainage across highway embankments, thereby, removing an impediment to free water exchange in a wetland area.

The exact cost/benefit ratio is difficult to determine for such usage. The availability of the photographs has certainly reduced the cost of highway improvements over an extended period. It has also allowed the identification of probelm areas in advance of highway construction, whereas without the photographs highway access would have been a prerequisite to even learning of a potential problem. Landsat data has the added advantage of a greater areal coverage than that which could be surveyed on the ground.

The proposed landsat follow on technology is potentially more useful to the Department than the current data. The greater resolution is important for specific areas of interest, as is the more timely coverage. We also anticipate that thermal infrared coverage will provide more meaningful data for our particular uses. These improvements should allow us to track growth cycles of various plant indicator species with greater precision.

Currently there are no formal programs or committment of funds for the use of NASA photoimagery on a daily basis. This is primarily due to the lack of ready access and the higher cost

-continued-

of these data. When these impediments are overcome, we anticipate a greater usage within the Department.

We would appreciate being informed of any future improvements in the system which would increase the capabilities of the landsat system.

Yours very truly,

E. J. BRECKWOLDT, P. E.
MATERIALS & RESEARCH ENGINEER

G. H. Cramer

G. H. CRAMER, II
HIGHWAY ENVIRONMENTAL ANALYST

GHC:mcb

cc: Russel L. Schweickart, Director
User Affairs
Office of Applications
NASA
Washington, D.C. 20546

Charles A. Whitehurst, PhD
Science Advisor to the Governor
Executive Department
Baton Rouge, Louisiana

Gary North, Director
Engineering and Science Services Laboratory
National Space Technology Laboratories
Bay St. Louis, Mississippi 39520

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Info Copy to EK
ED
ED-M
ER
Rec'd in Code E 5/11
Control Number
Suspense Date
Prepare Reply for
Signature of

State of Louisiana

OFFICE OF THE GOVERNOR

DIVISION OF ADMINISTRATION

II-C(11-6)

EDWIN EDWARDS
GOVERNOR

CHARLES E ROEMER, II
COMMISSIONER
AND
EXECUTIVE ASSISTANT TO THE GOVERNOR

April 27, 1976

Dr. James C. Fletcher
Administrator
NASA
Washington, D. C. 20546

Dear Dr. Fletcher:

I wish to convey my support of the proposed NASA LANDSAT Follow-On System. I am familiar with the LANDSAT program through our Louisiana Technology Transfer Office at NSTL, Bay St. Louis. We utilize LANDSAT data in many phases of state government, and appreciate the value of this timely information upon which we have based many major decisions. Decisions affecting not only the expenditure of great sums of money, but also the day-to-day lives of the citizens of our State.

Our Louisiana Forestry Commission uses this information as a tool in making inventories of state reserves, as well as for planning purposes and also to detect any diseased stands of our natural resources.

In conjunction with the State Planning Office, the Louisiana Technology Transfer Office provided flood assessment damage during the recent floods of 1974. This information, provided to us within 48 hours, was invaluable in our request for immediate disaster relief for those citizens affected most seriously by the flood. By having this information available in such a short time, we were able to expedite the securing of this release.

By comparison, in the 1973 flood acreage assessment it was some months before information was available in order to submit proposals for disaster relief.

Others areas using LANDSAT information include the Department of Highways North South highway proposal; coastal zone projections and zone management information as well as Superport environmental monitoring.

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Signature of

I encourage you in your implementation of this new program and pledge the State of Louisiana's continued use of all available NASA as well as NSTL technology through our Louisiana Technology Transfer Office. This institutional arrangement through our LTTO and NSTL has been a most valuable resource to the State of Louisiana and I encourage its continued operation.

Should you require any additional information or documentation, please call on me at your convenience.

Sincerely,

Charles E. Roemer, II

Charles E. Roemer, II
Commissioner of Administration and
Executive Assistant to the Governor

CERII:ge

cc: Mr. Russell L. Schweickart
Dr. Charles Whitehurst
Mr. Charles D'Agostino

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Action Copy to E
Info Copy to A, AD,
AA, ADA,
AC

A-25451

Rec'd in NASA 5-4-76

Suspense Date None
Prepare Reply for
Signature of —

Ref - A-25413

LOUISIANA STATE UNIVERSITY
AND AGRICULTURAL AND MECHANICAL COLLEGE

BATON ROUGE · LOUISIANA · 70803

LOUISIANA WATER RESOURCES RESEARCH INSTITUTE

AREA CODE 504
TELEPHONE 388-6003

April 14, 1976

Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration
Washington, D.C. 20546

Dear Dr. Fletcher:

The Louisiana Water Resources Research Institute (LWRRI) is responsible for encouraging original, purposeful water research and for promoting rational water resource management. Members of the Institutes Advisory Board represent the engineering, geological, legal and medical professions, as well as agriculture and industry.

During the past 5 years LWRRI has had a close working relationship with NASA personnel from the Earth Resources Laboratory, NSTL, Mississippi. We in the Institute appreciate this relationship and heartily endorse the proposed LANDSAT-Follow-On System; it will improve the opportunities for interaction and cooperation. Our projects have included investigations of erosion on the coast, littoral current flows around jetties, saltwater intrustion, water quality surveys and a study of the impact of Mississippi River diversion into the Atchafalaya Basin. Remotely sensed imagery has played an important role in all of these studies.

We are now faced with new problems, most of them arising from, or directly related to, energy production. Oil and gas exploration, lignite strip mining, and proposed agri-fuel farms will effect our water resources. The need for accurate and timely data in decision making relative to these operations is apparent. Base line studies are important and the proposed LANDSAT Follow-On System could assist us in defining the base data. More importantly, changes to the data, especially relative to the proposed mining operations are needed at the local level (as well as in state agencies) so that proper steps can be taken to maintain a viable water resource in any area.

We anticipate working closely with the Center for Wetlands Research when they obtain the LANDSAT-1 land classification system. (It is my understanding that this system will be adopted by CWR this coming year.)

LWRRI has representatives on most of the States Regional Planning Commissions, the Corps of Engineers Metropolitan Area Study, and other state agencies. Information received from the proposed LANDSAT system would be incorporated where possible into the operations of these agencies.

Dr. James C. Fletcher, Administrator
Page 2
April 14, 1976

LWRRI encourages the adoption of the new system. If we can be of assistance in any way, please call me or my staff.

Sincerely,

Elvin J. Dantin, Director
Louisiana Water Resources Research Institute

kb

cc: Russell L. Schweickart, Director
User Affairs
Office of Applications
NASA
Washington, D.C. 20546

State of Louisiana

OFFICE OF THE GOVERNOR

DIVISION OF ADMINISTRATION

TECHNOLOGY TRANSFER OFFICE

II-C(11-8)

EDWIN EDWARDS
GOVERNOR
CHARLES E. ROEMER, II
COMMISSIONER
AND
ECUTIVE ASSISTANT TO THE GOVERNOR
JAMES H. CLINTON
JOINT POLICY COUNCIL MEMBER

May 3, 1976

CHARLES F. D...
DIRECTOR
LEE W. JENNINGS
ASSISTANT DIRECTOR
AND
BATON ROUGE COORDINATOR

Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

The Louisiana Technology Transfer Office (LTTO) was established by Governor Edwin Edwards as the agency for facilitating technology application and utilization in Louisiana. The LTTO working with NASA and the National Science Foundation has established an office at the NASA/National Space Technology Laboratories in Bay St. Louis, Mississippi. Through this office, Louisiana is aware of the current LANDSAT program and is excited about the increased capabilities of the proposed LANDSAT Follow-On System.

The LTTO, which serves as a technology broker for Louisiana governmental agencies and industry, has documented many LANDSAT users. Among these are the Louisiana Department of Highways, using LANDSAT data for highway planning, and the Louisiana Forestry Commission, using LANDSAT data for crop inventory analysis.

In addition, the Louisiana Offshore Terminal Authority, which is charged with the environmental monitoring of the Louisiana Superport site, is currently working on plans for implementing a Satellite Environmental Monitoring System on State computers. This project will make LANDSAT available to many state agencies and other potential users in Louisiana. This effort will bridge the technology gap between the State and Federal Government by providing technology transfer in its purest form.

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Signature of ______

Other important uses for LANDSAT include quick response disaster programs such as the Mississippi River Flood Analysis and the Hurricane Carmen Damage Assessment. Also, the Louisiana Coastal Zone Management Program will rely heavily on future LANDSAT programs.

Now that Louisiana is making an effort to incorporate the current LANDSAT land classification system into the State information system, the proposed follow-on system adds more excitement and meaning to this technology advancement.

Please call if more information or documentation is desired.

Sincerely,

Charles F. D'Agostino

Charles F. D'Agostino
Director

CFD:bc

cc: Mr. Russell L. Schweickart
Dr. Charles A. Whitehurst

Action Copy to E
Info Copy to A, AD,
AA
A-25483 ADA
Rec'd in NASA 5-6-76

Suspense Date none
Prepare Reply for
Signature of

II-C(11-9)

State of Louisiana

OFFICE OF THE GOVERNOR

DIVISION OF ADMINISTRATION

EDWIN EDWARDS
GOVERNOR

CHARLES E. ROEMER II
COMMISSIONER

JAMES H. CLINTON
ASST. TO THE
COMMISSIONER

April 27, 1976

Dr. James C. Fletcher
Administrator
NASA
Washington, D. C. 20546

Dear Dr. Fletcher:

I believe the new NASA LANDSAT Follow-On System can only enhance the utilization of this already-appreciated resource.

As a joint policy council member for the Louisiana Technology Transfer Office, I have witnessed the application of this data in state government. Such agencies as the Forestry Commission, State Planning Office, Department of Highways and the Superport Authority have used this information to great advantage for the citizens of Louisiana.

LANDSAT data would be vital in environmental quality monitoring for the Superport Authority, and we hope to establish a system based on it.

As Commissioner Charles E. Roemer, II has continued to support the Louisiana Technology Transfer Office at NSTL, Bay St. Louis, making LANDSAT data available to all prospective state users, we are very much in favor of your proposal to improve the system.

If I can be of any assistance to you, please do not hesitate to call upon me.

Sincerely,

James H. Clinton
Assistant to the Commissioner and
Joint Policy Council Member

cc: Mr. Russell L. Schweickart
Dr. Charles Whitehurst
Mr. Charles D'Agostino

MARYLAND
DEPARTMENT OF STATE PLANNING
301 WEST PRESTON STREET
BALTIMORE, MARYLAND 21201
TELEPHONE. 301-383-2451

MARVIN MANDEL
GOVERNOR

VLADIMIR A WAHBE
SECRETARY OF STATE PLANNING

August 3, 1976

Action Copy to EK
Info Copy to ER
E
ED

Rec'd in Code E 8/26
Control Number E-535
Suspense Date 9/2
Prepare Reply for
Signature of E

Dr. James C. Fletcher
National Aeronautics and Space
Administration
Washington, D.C. 20546

ORIGINAL PAGE IS
OF POOR QUALITY

Dear Dr. Fletcher:

The State of Maryland has been involved with remote sensing as a means of gathering data useful for land use mapping, studies of critical areas and land capability/suitability analysis since 1971. At that time, the Department of State Planning was an experimenter on a NASA-ERTS-1 demonstration project.

The Department is still committed to the utilization of data obtained through remote sensing techniques as was indicated in our Final Report (Contract No. NAS5-21779 ERTS-1 Investigation #261). We support the expansion of a continuous role for remotely sensed data in planning programs.

The Director of the Comprehensive State Planning Division, Edwin L. Thomas, attended a recent meeting of the Remote Sensing Task Force of the National Conference of State Legislatures. The comments offered by the Department at that session reenforce our commitment. It is our belief that the Landsat Follow-On Program will provide the means necessary to fulfill the Department's long term objectives in the area of remotely sensed data utilization.

We see the inclusion of greater spatial and spectral resolution in the Landsat Follow-On Program as particularly important. The Thematic Mapper with its 5 bands and 30 meter spatial resolution is indispensable in increasing the utility of this data to sub-state jurisdictions. With it, area wide and county land use planning along with growth management would be placed firmly within the remote sensing perspective.

The advantages of remote sensing noted in our final report to NASA would be even more significant under the Landsat Follow-On Program. Specifically, the proposed improved sensor and system capabilities would permit greater:

1. Standardization of data collection and reporting techniques
2. Timeliness of information, speed
3. Change detection
4. Substitution for other data sources
5. Updating capability
6. Quick look - discovery of areas needing more detailed examination
7. Economy - prevent duplication

8. Reliability (lacking ambiguity)
9. Accessibility
10. Accuracy without ambiguity

Sufficient continuity exists between the Landsat C System and the Landsat Follow-On Program to insure data continuity for the most part. We noted that a decrease in the period of time between data acquisition and availability to the user is proposed. In this regard, the Department has recommended that more training is needed along with increased equipment availability and technical aid to adequately handle the increased amounts of data.

For your information, I am sending you a copy of a statement which Senator Mathias placed in the Congressional Record of June 23, 1975 regarding our ERTS experiment.

The Department supports the proposed Landsat Follow-On Program; it is imperative that this program planning continue because it provides a positive climate for existing and short term remote sensing data utilization activities.

Thank you for your assistance in this matter.

Sincerely,

Vladimir Wahbe

nb: letter; Governor Mandel to Maryland Congressional Delegation
Enclosure

cc: Senator Charles McC. Mathias
Senator J. Glenn Beall
Congressman Robert E. Bauman
Congressman Clarence D. Long
Congressman Paul Sarbanes
Congresswoman Marjorie S. Holt
Congresswoman Gladys Noon Spellman
Congressman Goodloe Byron
Congressman Parren Mitchell
Congressman Gilbert Gude
Delegate J. Hugh Nichols

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EH
ADA
B-C
A-28054
Rec'd in NASA 8/25/76
Suspense Date 9/9/76
Prepare Reply for
Signature of E

Dear

The State of Maryland has participated in a variety of programs designed to employ the latest technological advances. I feel that the Department of State Planning's involvement in the NASA-ERTS-1 demonstration project, which utilized data gathered by a satellite in earth orbit, is an outstanding example of such a program. Up-to-date land use mapping for the entire State has been completed under this program. This information along with other inputs will assist in the production of a State Generalized Land Use Plan.

Based upon the information available at this time, we support the NASA Landsat Follow-On Program. We recognize that several questions still remain including difficulties concerning data processing capability; however, overall program effectiveness would not be hampered when these matters are finalized.

The data produced by Landsat have proved to be quite valuable to the State of Maryland. The changes proposed for the Landsat Follow-On Program would provide the greater detail needed to make it even more valuable to State level planning agencies. The improved resolution and frequency of coverage would permit improved studies of forest defoliation, water quality, land use change in dynamic areas, shoreline development and change, as well as land form and geologic analysis.

It is essential that NASA be allocated sufficient funds to sustain the Landsat Follow-On Program. Our research has demonstrated that the total costs to acquire, process, interpret, handle, and map USGS Level I land use data are approximately thirteen (13) times greater if ERTS is not utilized. These reduced costs will assist all levels of government in increasing the benefits returned to their residents for each tax dollar collected.

The Landsat Follow-On Program is a logical and beneficial extension of existing programs. The advances made under this original NASA-ERTS-1 project should not be blunted by failing to support this program. Our experience has shown that reduced costs and increased benefits have resulted from the use of data gathered by satellites in earth orbit. With respect to this program one can certainly say that the future is now.

Thank you for your consideration of this matter.

Sincerely,

Governor

MM/hej

cc: Vladimir A. Wahbe

Sent out 8/11/76

United States of America

Congressional Record

PROCEEDINGS AND DEBATES OF THE 94th CONGRESS, FIRST SESSION

Vol. 121 WASHINGTON, MONDAY, JUNE 23, 1975 No. 100

Senate

MONDAY, JUNE 23, 1975

SATELLITE OVER MARYLAND

Mr MATHIAS. Mr. President, I wish to call the attention of the Senate to a very interesting example of the application of NASA-developed technology for the direct use and benefit of people and local government. The Maryland Department of State Planning and Earth Satellite Corporation have published the results of an expirment entitled "Application of ERTS-1 Data to Integrated State Planning in the State of Maryland " This was a joint public agency-private corporation effort to examine, test, and apply remotely sensed data from satellites and other sensors in the realistic setting of a statewide general land-use plan program Additional input to the study was procured by the use of high aircraft imagery for more detailed results

This 200-page document should be very important reading for land-use planners on all levels of Government It shows that NASA satellite data has a demonstrated capability to produce land-use information on a par with U S. Geodetic Survey information at a cost substantially lower than the cost to produce similar information by traditional means Maryland was a most exacting test case for the application of satellite data as it is a small densely settled, and diversely landscaped State and this study concludes that in environments of less complexity much higher use levels will be realized for satellite-produced data.

We do not today know all of the uses to which satellite-produced data can be put This is a new field and a growing one. I commend to any interested party that they review this study as it may well serve as a baseline program for other States and regions to look at and to benefit from in the many ways that are portrayed throughout the report. I am sure that Mr. Vladimir Wahbe secretary of the Maryland Department of State Planning in Baltimore, and others associated with this department in the preparation of this study, would be pleased to receive inquiries and to supply information about it

II-C(12-2)

LOUIS N. PHIPPS, JR.
DEPUTY SECRETARY

STATE OF MARYLAND
DEPARTMENT OF NATURAL RESOURCES
TAWES STATE OFFICE BUILDING
ANNAPOLIS 21401
May 3, 1976

Action Copy to EK
Info Copy to ER
ED
ED-11

Rec'd in Code E 5/12
Control Number
Suspense Date
Prepare Reply for
Signature of

Dr. James C. Fletcher, Administrator
NASA/Goddard Space Flight Center
Greenbelt Road
Greenbelt, Maryland 20771

ORIGINAL PAGE IS
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Dear Dr. Fletcher:

The State of Maryland is appreciative of the applications of Landsat data which has been generated at the NASA/Goddard Space Flight Center.

The specific application to which I refer is a mined land inventory of Western Maryland using Landsat data. The investigation was done by Arthur T. Andersen, NASA/Goddard, who worked in close collaboration with Maryland Geological Survey personnel.

The methodology worked out by Mr. Anderson provides the State of Maryland with a rapid, cost-effective program for inventorying the mined lands in the coal region in our westernmost counties. This rapid mapping technique will make it possible to inventory the land mined in the area over a given period of time and has potential in identifying the quality of reclamation in areas where mines have been backfilled and revegetated.

The inventorying technique will assist the Maryland Bureau of Mines in its regulatory and management functions because it will provide a rapid update and cross-reference for field determined mining and reclamation data.

We feel that significant savings may accrue to the state from the developmen of this Landsat technique. If the Landsat data could not be used, other methods such as aerial photography on a periodic basis would have to be applied. Althoug aerial photographs may lead to more precise measurements of mined land, it would also be considerably more expensive.

We are now considering various means of putting the methodology developed by Mr. Anderson into operational use including assigning one of our geologists to work with Mr. Anderson at NASA/Goddard for a short period to familiarize himself with the hardware and software applications.

We are looking forward to other possible follow-on activities including collaboration with NASA/Goddard in expanding the methodology of mined land invento developed in the coal regions of the state to those areas which have been affected by other types of mineral operations.

Sincerely yours,

James B. Coulter
Secretary

JBC:jd

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AA
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AC X
Rec'd in NASA 5-7-76

Suspense Date None
Prepare Reply for —
Signature of

HOUSE OF DELEGATES
ANNAPOLIS, MARYLAND 21401

J. HUGH NICHOLS
HOWARD COUNTY
COMMITTEE ON APPROPRIATIONS

COUNTY ADDRESS:
6117 SEBRING DRIVE
COLUMBIA, MARYLAND 21044

July 2, 1976

Dr. James C. Fletcher, Administrator
NASA/Headquarters
Code A
Washington, D.C. 20546

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Dear Dr. Fletcher:

As you are probably aware, the National Conference of State Legislatures' Task Force on Satellite Remote Sensing for State Policy Formulation is completing an analysis of the past and possible future uses of satellite imagery in State applications. A final report will be forthcoming shortly.

In the meantime, I thought you might be interested in my impressions as Chairman of the Task Force. The members were very enthusiastic about the potential applications of this technology. A wide range of existing applications was reported. There is, however, an even wider range of potential applications but many State policy makers are hesitant to make the expenditures to implement them because of the uncertain availability of data.

Therefore, I believe it is very important that a commitment be made to the LANDSAT Follow-On project as soon as possible and that this information be made available to the States, possibly through the National Governors Conference and the National Conference of State Legislatures. Early knowledge of NASA's commitment will provide them the necessary lead time and will permit them to make the necessary investment decisions to take full advantage of the wealth of resource data on an on-going, operational basis.

The last meeting of the Task Force was held in my own State and I believe the enclosed letter from the Director of our Energy and Coastal Zone Administration is a good example of the general impressions set forth above.

Sincerely,

J. Hugh Nichols

Encl:
cc: Rusty Schweickart

EXECUTIVE OFFICE
STATE OF MISSOURI
JEFFERSON CITY

CHRISTOPHER S. BOND
GOVERNOR

April 19, 1976

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Suspense Date 5/3
Prepare Reply for
Signature of A

Dr. James C. Fletcher
Administrator
National Aeronautics and
Space Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

The State of Missouri has been participating in various remote sensing activities with great interest. Some of our activities and plans for the future evidence our interest in the future availability of satellite data and are summarized in the attached statement provided by the University of Missouri - Rolla.

Missouri looks forward to the continued availability of satellite images which we are finding of extreme importance to many of our state agency programs.

Sincerely,

Christopher S. Bond

GOVERNOR

prw

Enclosure (bulky not retained in AEM-3)

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Rec'd in NASA 4-22-76

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SUMMARY OF ACTIVITIES AND

PLANS FOR THE FUTURE

PROVIDED BY

UNIVERSITY OF MISSOURI - ROLLA

Missouri became involved in the early NASA sponsored and funded aircraft programs. A number of NASA flights were obtained by researchers at the University of Missouri and the Missouri Geological Survey during this pre-satellite program. Much useful information was acquired regarding the geology, soils and existing land use in specific areas of the state.

In 1973 Governor Bond appointed a Committee on Remote Sensing reporting to the Governor's office, which reviewed the need for cataloging remote sensing data, determining user needs and developing an organized educational program. This committee was later reorganized as the Interdepartmental Council on Natural Resources Information. Through the efforts of the Council and the University of Missouri, two remote sensing conferences directed toward application were held in 1974 and 1975. Course work developed at the University of Missouri and a remote sensing laboratory developed at the University of Missouri - Rolla have been supported by grants, loaned equipment, and advice from NASA and the USGS. Additionally, two detailed workshops to provide hands-on experience with remote sensing techniques and products have been held. These workshops were attended primarily by personnel of state agencies, and a number of specific projects have been initiated as a result of workshops.

One project has been an inventory of the Grand Platte River Basin by personnel from the Missouri Department of Conservation. Landsat I images were used to determine the forested areas of this river basin. Additional work has shown that the 7 1/2 minute quadrangle maps can be updated to include the forest areas. Satellite images were supplemented with aerial photography to produce an analysis of the type of timber, and estimate of production and an evaluation of wildlife and recreational potential This project was summarized in a report entitled "Procedures for th Grand Platte River Basin, Multiple-Objective Land Use Planning Study" issued in July 1975.

The Soil Conservation Service became interested in the use of Landsat images for developing an updated general soils map of our state. A contract for over $20,000 was developed with the Laboratory for Applications of Remote Sensing (LARS) at Purdue University to provide computer analysis and output of the Central Missouri area for this purpose. Evaluation of this output is continuing, and it appears satisfactory to the point where consideration is being given to an analysis of the entire state. This information has been extremely helpful in the soil mapping program, a cooperative effort between SCS, the University of Missouri Agricultural Experiment Station and the Forest Service, to provide detailed soil maps of the entire state.

Another important project which was an outgrowth of the earlier Governor's Committee on Remote Sensing has been the indexing of all aerial and space images over Missouri. This effort was funded by the Rural Development Center at the University of Missouri. A copy of the publication from this project entitled "Index to Aerial and Space Photographic Coverage of Missouri" is enclosed. This work summarizes all of the available federal, state, and private aerial photography, as well as Landsat and Skylab images taken over Missouri. Future workshops on remote sensing will make extensive use of this publication.

The index has already been extremely helpful to the Soil Conservation Service. The knowledge of existing high altitude photography has saved them over forty thousand dollars in two counties where they could order existing photography rather than schedule a reflight by their agency. This one cost saving is more than three times the cost of developing and publishing the index.

A remote sensing applications committee of the council is reviewing the need for a state remote sensing information center. The committee is also charged with the responsibility for identifying remote sensing research needs and providing coordination of remote sensing products among our state agencies.

NASA Technology Transfer Grants issued to the University of Missouri and the Department of Natural Resources are developing the procedures for manually producing Level 1 land use maps from Landsat images. Emphasis is also placed on organizing workshops for training of local, county and regional professional staff in the use of Landsat images. Additionally, the contracts will look at the possibility of digitizing the aerial photography and space image indexes to provide a current update and more flexible utilization of that product.

A study of the Mississippi River being conducted by the University of Missouri - Rolla for the Corps of Engineers, which draws upon NASA data, is also of interest to this state. The serious floods of 1973 and 1974 point the need for this important study. The effect of the river on commerce and the economy of our state is of obvious importance.

The future satellite remote sensing systems are of interest to many of our state agencies. The increase in resolution from 70 meters to 30 meters of future systems will greatly enhance the detail and the planned use of these images. The soil mapping program, as indicated previously, would greatly be accelerated with the increased resolution. Our Department of Natural Resources and Department of Conservation are interested in a current inventory of our timber resources within the state. The assessment of the quantity and quality of this resource would greatly improve our ability to adjust our manpower and resource needs for the wood products industry.

The U.S. policy for all-out food production has had a direct effect on agriculture in Missouri. We are aware that pasture lands in the northern part of the state have been plowed up and planted to row crops. In our Ozark Region in the southern part of the state timber and brushland areas have been converted to pasture. We are in need of information relative to the extent of these changes in order that our agricultural programs might be appropriately adjusted.

There are certain episodical events such as drought and storm damage to crops which are also important to our Department of Agriculture. We would anticipate the use of satellite images to assist us in determining the regional consequences of such events. An inventory of our irrigated lands, especially in dry years, would also be extremely helpful. Many of our current yield models consider only moisture and temperature, and, therefore, emphasize the need for knowledge of irrigated acres.

The Office of Administration has the responsibility for the land use planning function of the state. The knowledge of current existing land use is extremely important in land use decisions. The Landsat information provides a way of readily updating land use changes and assists in verifying any prediction trends.

The mining industry is extremely important to Missouri. Geologists have been able to use the Landsat images to broaden the effectiveness of mineral exploration. A mine land inventory is currently being conducted to assess the total number of acres involved. We are also especially interested in the number of acres which have been reclaimed and the amount of reclamation which needs to be considered in the future. The NASA Applications Transfer Grant will greatly assist this effort and demonstrate the applicability of Landsat data in the management of mineral lands of the state.

An increase in expenditures for the use of remotely sensed data is anticipated. It is difficult to forecast an exact dollar amount as of this date. The input from the Interagency Council on Natural Resources, as well as approval by the heads of the different state agencies, will be considered.

C (14) NORTH
dakota

REGIONAL ENVIRONMENTAL ASSESSMENT PROGRAM
REAP
Resources Environment Knowledge People
The Future

316 North Fifth Street, Room 521 - Bismarck, North Dakota 58505
Telephone (701) 224-3700

A. William Johnson, Director

July 7, 1976

Dr. James C. Fletcher, Administrator
National Aeronautics and Space
Administration
Washington, D.C. 20546

ORIGINAL PAGE IS
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Dear Dr. Fletcher:

I am submitting this letter to be used as a testimonial in support of the NASA request to the Congress for approval of a LANDSAT follow-on program. Within the last two months the North Dakota Regional Environmental Assessment Program has made a major financial and programmatic commitment for the long-term utilization of LANDSAT information as a cornerstone of our geobased statewide environmental assessment system. We are utilizing this system to develop a land cover analysis for the entire State of North Dakota, and presently have an existent contract for the acquisition of such data, of 1974 and 1975 vintage, to provide a baseline for that analysis. One of the major reasons for selecting the LANDSAT capability, over other options we had available to us, was the expectation that changes in land cover could effectively be monitored through LANDSAT imagery over an extended period of time.

The REAP program was established by the Legislative Assembly of the State of North Dakota in 1975. It is to provide for the state a comprehensive system for environmental, socioeconomic, and sociologic data acquisition, for the integrated assessment and forecasting of impacts, and for the monitoring of changes in baseline characteristics. The legislation provides specific mandates to REAP and outlines the purposes to be served by the REAP system. Rather than detailing this information in this letter, I enclose a copy of a document entitled "REAP Synopsis" which outlines briefly the history, the mandates, the purposes, and the activities of REAP. That document was dated January 1976 and a number of these activities are much further along than implied by that document. Specifically, we now have in force $1.2 million worth of contracts with a variety of organizations for the acquisition and gathering together of baseline data in the general subject areas of air quality-meteorology, animals, geology, historic-archaeologic-paleontologic sites, land cover analysis, social impact socioeconomic impact, soils, vegetation, and water. One of these

contracts, totaling approximately $140,000, is for a complete land cover analysis of the State of North Dakota using 1974 and 1975 LANDSAT imagery. This analysis is to be complete by October 25, 1976, and will result in the preparation of hard copy county land cover maps, as well as a digital tape containing land cover information aggregated to 40-acre cells. It is our intent that this tape information, particularly, serve as a beginning baseline for a long-term monitoring effort which should provide exact information on the nature of land use changes within the state. As you may be aware, there are a large number of issues of concern in the state related to land use, issues such as wetlands, reclamation practices, the extent of strip mining, urban sprawl, reduction in amount of native prairie left undisturbed, etc. It is my hope to interest NASA in participation in this monitoring effort.

REAP is approximately one year old at this point. One of our major ongoing efforts has been the design of a computer-based system for the storage, retrieval, and analysis of information on the subject characteristics mentioned above. Our system design effort is well along at this point and is to be completed by October 18, 1976. It is our intent to implement a geobased information system pertaining to the various subjects mentioned above so that we may accurately describe "what is" with regard to the State of North Dakota and its subdivisions. In addition, we expect to utilize this system as a base for projecting the expected impact created by a variety of development scenarios. Whether the issue be the extent of irrigation, the extent of coal strip mining, the development of potash solution mining, or a host of other issues, the basic subject characteristics mentioned above all are important in the consideration of the alternatives available to the state.

At the present time we have made the commitment to use of the LANDSAT system to satisfy our major land cover analysis needs. This information will be used in decisionmaking on the statewide level, at the county level, and at the regional planning level. The agencies which will be involved in the utilization of this data are the legislature itself, executive branch agencies, and several levels of local government. We had an opportunity to enter into a contract with the U.S. Geological Survey to utilize their LUDA program, but one of the major factors in our turning to LANDSAT instead was the likelihood, and certainly the hope, that such a system would have a long-term existence and would thereby be able to produce comparable data for the assessment of land cover changes. At the present time our effort is financed 100 percent by state appropriation.

We have already elicited a great deal of interest amongst local government within the State of North Dakota for utilization of this data, and, in fact, have received financial contributions from one regional planning council and from the state agency responsible for EPA "208" water quality management efforts, particularly those dealing with non-point source pollution.

I hope that the information provided above has indicated that the State of North Dakota has made a major commitment to the utilization of LANDSAT imagery, and has proceeded well beyond simply making a commitment, but actually has a dollar investment. We are incorporating the availability of LANDSAT information into our overall REAP system design. If LANDSAT imagery is not to continue to be available, a very serious impact will have been created on the REAP system. I think there is general agreement around the country that LANDSAT analysis is probably the most accurate, and certainly the most cost effective means, for carrying out land cover analysis on large realtively open areas such as we find in the State of North Dakota. It is my sincere hope that the flow of LANDSAT imagery will not be interrupted.

Sincerely yours,

A. William Johnson

A. William Johnson, Ph.D.
Director

AWJ:amb
Enclosure
cc: Mr. Russell L. Schweikart
Mr. Stanley C. Freden

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REAP Synopsis

The North Dakota Regional Environmental Assessment Program (REAP) is an innovative program which could serve as a model for other states and regions. It will provide a comprehensive system for environmental, socioeconomic, and sociologic data acquisition; for the integrated assessment and forecasting of impacts on these characteristics arising from potential development activities; and for the monitoring of these characteristics. REAP will coordinate the results of the myriad studies underway, will initiate its own studies where appropriate, and will make the results of all available in a usable format to decision makers.

Four main tasks will be undertaken to provide North Dakota decision makers with facts rather than speculation upon which to base decisions affecting the citizens of the state. The four tasks are: 1) Baseline data acquisition; 2) Information system design; 3) Assessment/simulation/modelling design; and 4) Monitoring system establishment.

The idea for such a capability in North Dakota arose in 1974, when, realizing the need for an accurate and coordinated information and forecasting tool for decision makers, the North Dakota Legislative Council contracted with Battelle's Columbus Laboratories to design a comprehensive system. The firm prepared and presented to the Resources Development Committee (RDC) a report suggesting the design and structure for a "Regional Environmental Assessment Program." In October 1974 the concept was approved by the RDC and in November a draft bill was prepared.

On April 10, 1975, Governor Arthur Link signed House Bill 1004 which established the North Dakota REAP and provided an appropriation of $2 million from a special coal development fund (obtained from coal severance taxes), plus such other federal or private funds as may become available.

As stated in HB 1004, REAP is charged with " . . . establishing and carrying on research in regard to North Dakota's resources . . . for the purpose of assisting in the development of new laws, policies and governmental actions and providing facts and information to the citizens of the state." Further, REAP is responsible for " . . . the development of necessary data and information systems in regard to the existence of and potential use of North Dakota's natural resources in order that (North Dakotans) . . . may know . . . the alternatives available to the state in any use and development of resources in order that . . . any such use shall in fact enhance the quality of life of the citizens of the state."

The Legislative Council appointed a Resources Research Committee (RRC) to be responsible for implementing the program. The RRC consists of three state Senators, two state Representatives, five representatives of state agencies in the executive branch, two representatives of the universities, and one citizen-at-large. A director and small staff have been appointed.

In August 1975, the REAP director formed the Technical Advisory Council (TAC) comprised of selected specialists in various fields to provide overview advice to REAP on its programs and projects and to assist in evaluating proposals and completed projects.

(over)

The director also formed technical task forces (TTF's), comprising specialists from universities, state and federal agencies, and industry, in 11 subject areas to begin assessing the priorities for data acquisition and compilation. The TTF areas of study were air quality-meteorology, animals, geology, historical-archeological-paleontological, land use, noise-radiation-solid waste, social impact-quality of life, socio-economic impact, soils, vegetation, and water. Nine of these task forces met in the Fall of 1975 under the direction of REAP's two associate directors. The report of these TTF's was completed December 8 and, after review by the TAC, was presented to the Resources Research Committee on December 18, 1975. This report provided the basis for REAP staff selection of priority study projects.

After a review of the capabilities and interests of several firms in August and September 1975, IBM Federal Systems Division was chosen to conduct a system design study for REAP. Phase I of the study provided for appraisal of the computer sites available to REAP, preliminary design of REAP interim capability, and a requirements analysis and conceptual design for the entire REAP system.

At its December 18-19 meeting, the RRC took a number of steps which begin to shape an operational REAP.

First, the committee approved the recommendation of IBM/FSD and the REAP staff that the Central Data Processing Division of the Department of Accounts and Purchases in Bismarck, with its IBM 370/145 computer, be selected as the computer site for REAP.

Second, the RRC directed the staff to take the steps necessary to implement two interim capabilities such that they be in operation before November 1, 1976. The first will be a computer-based REAP Resource Reference System (R^3S) which will provide on-line access to information relating to resource analysis and development. The second will be the initial module of an econometric-demographic (E-D) model, capable of forecasting certain economic and demographic changes in North Dakota and its political subdivisions.

Third, the RRC concurred with the overall conceptual design for REAP as formulated through Phase I of the IBM/FSD contract. It also authorized the continuance of the design work through Phase II of the contract.

Fourth, the RRC directed the REAP staff to arrange for the commencing of baseline data acquisition studies in nearly all TTF areas in accord with the priority list presented. Existent data will be evaluated and new data will be obtained through these efforts.

These actions by the Resources Research Committee initiate efforts to address all four main tasks assigned to REAP. While implementation of the full REAP system is a multi-year effort, the steps taken to date will assure the provision of both an information capability and an analysis capability by January 1977.

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STATE OF OHIO
OFFICE OF THE GOVERNOR
COLUMBUS 43215

JAMES A RHODES
GOVERNOR

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July 15, 1976

Dr. James C. Fletcher
Administrator of NASA
Code A
Washington, D.C. 20546

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Dear Dr. Fletcher:

The State of Ohio is a progressive state in both the utilization and the protection of its resources. As such, geophysical, social and economic data processed into information meaningful to the decision and policy making elements of state, local governments and regional agencies is of great importance. However, the choice of an operational system of information for resource management draws from measures of information value such as cost, timeliness, and ease of generation.

Over the past five years, the State of Ohio has examined the application of earth resources observation systems and we have established the capability to utilize the significant attributes of these systems for information concerning Ohio's resources. Specifically, in the case of the Landsat system, the state is using this data to develop and continually monitor land use in the state. We are relying upon the future availability of Landsat data to update this cost effective statewide land use inventory.

Because of these experiences, programs utilizing the satellite system will continue to have my support and encouragement.

Sincerely,

James A. Rhodes

JAMES A. RHODES
Governor

JAR/dab

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Suspense Date

State of Ohio Environmental Protection Agency, Box 1049, 361 East Broad Street, Columbus, Ohio 43216 (614) 466-85 II-C(15-2)

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Rec'd in NASA 7-19-76
Suspense Date 8-3-76
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Signature of E

OhioEPA

James A. Rhodes
Governor
Ned E. Williams, P.E.
Director

June 15, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters
Code A
Washington, D.C. 20546

Dear Dr. Fletcher:

As you are aware, the Ohio Environmental Protection Agency is participating with its sister agencies, the Department of Natural Resources and the Department of Economic and Community Development, in order to develop a statewide land use inventory using ERTS and LANDSAT data. I am most satisfied by the fact that my Office of the Planning Coordinator has informed me of the progress of this program to date toward realizing a statewide land use inventory with a land use categorical breakdown of sufficient detail to be utilized in several of our categorical environmental programs.

Principally, we expect to use the LANDSAT inventory in our wastewater program, particularly in the planning for Sections 201, 208 and perhaps 305(b). Each of these sections of the law requires some form of land use data manipulation in order to determine incremental five year projections over a 20 to 50 year timeframe. We anticipate the use of the LANDSAT data as being particularly informational as the state undertakes it obligation under Section 208 Areawide Waste Treatment Management Planning. The reason that LANDSAT data is so valuable in this context is that most of the state has no land use information and much of the land use information that is available is not broken into land use categories that are directly of assistance to OEPA in its planning efforts.

Another categorical program in which the Agency anticipates extensive use of LANDSAT information is in the air pollution control program. The APC office is charged with responsibility of statewide air quality planning and monitors and supports the various regional air pollution control authorities throughout the state. The particular concern of the air program in utilizing LANDSAT land use information is for the state's participation in implementation

of the air quality maintenance area program and associated non-degradation objectives. It appears to me that both the wastewater program and the air program reflect an intensive land use planning and analysis activity on the part of the Ohio Environmental Protection Agency. As such, the LANDSAT program has tremendous potential both in terms of information gained and a tremendous opportunity in terms of minimizing the kinds of resources normally associated with development of such a data file. Although our LANDSAT program is not at a point where we have any finished products, we are anticipating some outputs within the next several weeks and as such look forward to realizing a long identified need within the state and its associated planning functions.

I would anticipate that the availability of LANDSAT information at the state level would also be readily available to particularly areawide and/or regional planning bodies who need virtually the same kind of information. It seems appropriate, however, that this information would require even further analysis and differentiation at the areawide or local level and as such the state is looking into the possibility of further specifications of LANDSAT information. It is my feeling that continuity of an environmental planning program is specifically maintained at the areawide and/or regional level. For instance, the 208 program and the local air agencies (as particular examples) are affected by day to day activities and decisions, therefore state land use planning, over time, would merely provide the overview and guidance to provide for homogeneity and equitability of state policies from area to area.

My Agency is, at the moment, seriously undertaking identification of further utilization of LANDSAT data within our non-designated (208) planning program as it relates directly to the nonpoint source water quality activities so necessary in order to incorporate its required implementation and management strategy at the areawide level. This activity would effectively integrate land use, water quality, demographic, cultural and engineering information banks into the nonpoint source assessment in an evaluative systems format.

In summary, this Agency is fully prepared to make many uses of the LANDSAT information, even to the extent that the new Drinking Water Quality Act delegations to the state require (again) similar kinds of land use information as is required in 208 and the air program, and that we fully anticipate being able to use it effectively and efficiently.

Very truly yours,

Ned E. Williams, P.E.
Director

NEW/mam

cc: Russell L. Schweickart
NASA Headquarters

ODNR
Ohio Department of Natural Resources
Fountain Square · Columbus Ohio 43224 · (614) 466-3770

July 15, 1976

Action Copy to EK
Info Copy to ER
E
ED-M

Rec'd ... 7/21
Control ... E-438
Suspense Date 7/29
Prepare Reply for Signature of E

Dr. James C. Fletcher, Administrator
National Aeronautic & Space Administration
NASA Headquarters, Code A
Washington, D. C. 20546

Dear Dr. Fletcher:

The purpose of this letter is to emphasize the importance of LANDSAT data to the State of Ohio, in particular my Department of Natural Resources, and to identify current and potential future use of these data. In general, we support fully the continuation and development of the program by NASA.

The Department is currently completing a statewide land use inventory based on the use of LANDSAT data. The economic and time-saving benefits of this program will be significant in our efforts.

Once our initial land use inventory has been completed and stored in digital form, we will have a base which can be readily used for various purposes. I believe that one excellent potential of these data is that changes in land use can be detected through updating of the information, various statistical information can be generated, and supplemental inputs can then be utilized for more detailed analysis of specific areas. As improvements are made in remote sensing and computer technologies, the land use inventory will reflect these improvements.

I believe that perhaps the most important aspect of utilizing LANDSAT data is that information is obtained from a single source using the same criteria over the entire state within a narrow span of time. This, as opposed to a myriad of sources working independently over long periods of time as in previous statewide inventories, has obvious advantages.

At present the Department has five staff people engaged in the preparation of the Ohio statewide land use inventory. Their backgrounds are in remote sensing, computer sciences, and regional planning. Various computer programs presently being used are compatible for use with the LANDSAT data, as are the various computer hardware elements. The initial inventory is expected to be completed by December 1976, with improvements and updating to be carried out from that time.

Dr. James C. Fletcher
July 15, 1976
Page 2

The results of the statewide land use inventory should be useful in areas other than land use planning; for example, in the determination of non-point pollution sources for the 208 water quality study, monitoring of surface mining, and determination of the progress of mine reclamation work.

In summary, we support the NASA effort in collecting LANDSAT data, and would like to assure you that we feel that these data have many potential uses in Ohio, some of which of course may not be fully realized at this time.

Sincerely,

Robert W. Teater

ROBERT W. TEATER
Director

RWT/cl

cc: Mr. Russell L. Schweickart
Director of User Affairs
NASA Headquarters
Code EK
Washington, D. C. 20546

Mr. Alex Tuyahov
NASA Headquarters
Code EK
Washington, D. C. 20546

Action Copy to E
Info Copy to A, AD
AA
A-27204 ADA
B
Rec'd in NASA 7-19-76
Suspense Date 8-3-76
Prepare Reply for
Signature of E

II-C(15-4)

STATE OF OHIO
James A. Rhodes, Governor
James A. Duerk, Director

Department of Economic
and Community Developmen
P.O. Box 1001 • Columbus, Ohio • 43216

July 27, 1976

Action Copy to EK
Info Copy to ER
E
ED-M

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters
Code A
Washington, D. C. 20546

8/4
E-
8/12
Signature E

Dear Dr. Fletcher:

The Department of Economic and Community Development is the coordinating agency for Ohio's utilization of satellite data. The results of past studies and the present Landsat work indicate several applications of interest to the State of Ohio. Of particular interest is the continuance of a land use inventory by this Department in cooperation with the Ohio Environmental Protection Agency and the Ohio Department of Natural Resources. The products of this effort are maps of land use for each county and township with detail to the one acre level. Tabulations of the amount and percentage of land use within each of these geographic boundaries are also available.

The expanding scope of state planning has created the need for an accurate, up-to-date comprehensive Ohio land use inventory. The inventory is applicable to a wide variety of new planning programs throughout state government and DECD. Specifically, development of statewide land use and growth policies requires a land use inventory as in input to decision making: HUD "701", Commerce "Coastal Zone Management" and EPA "Water Quality Planning" as required by Federal Interagency Land Use Agreements.

In order to generate this inventory in an economical, timely and uniformly accurate way, the Landsat satellite was chosen as the data acquisition system. Landsat married to machine processing techniques are providing the expected benefits.

A 1965 land use inventory cost $191,000, or roughly $310,000 in 1975 dollars, and took two years to produce from data ranging seven years apart. The present inventory is expected to cost approximately $115,000 and take one year to prepare. The prospect of a cost effective update capability relies on the availability of the Landsat data acquisition system.

The Ohio Statewide Land Use Inventory is a product with a long term clientele; state agencies responsible for planning and monitoring land use, regional planning agencies and local planning commissions. The product must be updated periodically and improved in an ongoing program requiring earth resource data. The Landsat system is the most cost effective data acquisition system available and continued availability is quite important to this Department's program.

In closing, we are interested in information that is appropriate, timely, and cost effective for day-to-day operations and for policy decisions. We have found the Landsat system to be an important component of a growing number of resource information systems. We encourage your continued efforts to improve its capability to provide economical, timely, and quality data.

Sincerely,

James A. Duerk

James A. Duerk
Director

Action Copy to E
Info Copy to A, AD
ADA, BA
927573 EC
B
Rec'd in NASA 8/2/76
Suspense Date 8/16/76
Prepare Reply for
Signature of E

C (16) OREGON

Action Copy to EK
Info Copy to ER
EP
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ER-M
Rec'd in Code E 6/15
Control Number E-330
Suspense Date 6/23
Prepare Reply for Signature of A

ROBERT W STRAUB
GOVERNOR

OFFICE OF THE GOVERNOR
STATE CAPITOL
SALEM 97310

June 11, 1976

Action Copy to E
Info Copy to AE
UG
AS
X
A-26289
Rec'd in NASA 6-15
Suspense Date 6-2
Prepare Reply for Signature of E

The Honorable Dr. James Fletcher
Administrator
National Aeronautics and Space Administration
Washington, D.C. 20546

ORIGINAL PAGE IS
OF POOR QUALITY

Dear Dr. Fletcher:

I have learned that NASA is now planning some advanced versions of the LANDSAT A and B systems now used in the Pacific Northwest Regional Commission Land Resource Inventory Project. We feel these new systems will provide a readily available source of land data for use by state natural resource agencies.

The States clearly have a need for timely and cost-effective natural resource information. Conventional methods require a great deal of time, energy and manpower. Because Oregon is heavily resource oriented, we are very concerned about the intelligent management of those resources, and we feel that satellite surveillance can be an effective tool in public management programs.

The LANDSAT demonstrations of our current Land Resources Inventory Project are not yet complete, but the results reported by the agencies involved are encouraging. We have five primary demonstrations within the project in Oregon, all of which are showing encouraging results.

The Department of Water Resources is monitoring the irrigated lands in the Klamath River Basin as a result of a regional compact between the states of Oregon and California. Conventional methods do not readily permit an assessment of the new irrigated acreage because the cost involved in performing the necessary surveys is prohibitive. However, results obtained in our satellite demonstration project are very accurate and will be helpful in the coming year.

The second project showing early results is one involving the noxious weed Tanzy Ragwort which infests sixteen counties in western Oregon. Livestock losses have been several million dollars per year. The extent of infestation of this weed has virtually precluded its control. The personnel from the Oregon Department of Agriculture have been encouraged by the results of the satellite work done in one test county in Western Oregon, and they are now expanding the project to cover the entire sixteen county area.

The State of Oregon will continue to explore LANDSAT data for Land Resources Planning and Management. We also expect that operational LANDSAT Follow-on systems will be utilized as a major source of data needed to effectively plan and manage the natural resources within the State of Oregon.

Sincerely,

Governor

RWS:bh

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STATE OF SOUTH DAKOTA

RICHARD F. KNEIP
GOVERNOR

EXECUTIVE OFFICE

PIERRE
57501

Action Copy to E
Info Copy to A, AD
AA
ADA
B
A-26488
Rec'd in NASA 7-12-76
Suspense Date 7-27-76
Prepare Reply for Signature of A

July 7, 1976

Action Copy to EK
Info Copy to E
ED
ED-M
ER
Rec'd in Code E 7/14/76
Control Number E-416
Suspense Date 7/21/76
Prepare Reply for Signature of E

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters
Code A
Washington, D. C. 20546

Dear Dr. Fletcher:

On behalf of state government and all the people of the state of South Dakota, I would like to express enthusiastic support for the proposed Landsat Follow-On program.

Several agencies in state and local government in South Dakota are currently involved in operational applications of Landsat data in land use and natural resource planning and management efforts. These applications have, by and large, proven to be very successful, and the value of Landsat imagery, in both digital and photographic formats, has been repeatedly demonstrated.

Recognizing the utility of this type of data, the State of South Dakota, the State Planning Bureau, and the Remote Sensing Institute have made considerable investments in the development of Landsat analysis procedures and software systems. The Planning Bureau, for example, has developed a Land Resource Information System based, in large part, upon Landsat digital data. These investments, while justifiable on the basis of the current satellite series (Landsat -1, -2 and -3), were made with a view toward the establishment of a second generation operational satellite series such as that proposed in the Follow-On program. It is our hope that the President and Congress will allow the full promise of satellite remote sensing for land resource planning and management to be realized. The Landsat Follow-On program clearly provides the best means of achieving that goal.

If my office or other agencies in state government can provide further support to the Follow-On program, please do not hesitate to contact Dan Bucks, Commissioner of the State Planning Bureau. Mr. Bucks, who will be coordinating South Dakota's input to OMB's program evaluation, is currently preparing additional support materials for your proposal.

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With best wishes for success in this endeavor, I remain

Sincerely,

RICHARD F. KNEIP
GOVERNOR

RFK/brd

cc: Rusty Schwickert
NASA Headquarters
Office of User Affairs
Code EK
Washington, D. C. 20546

Dan Bucks, Commissioner
State Planning Bureau
State Capitol
Pierre, SD 57501

II-C(17-2)

STATE PLANNING BUREAU
State Capitol
Pierre, South Dakota 57501
605/224-3661

SOUTH DAKOTA Office of
Executive Management

Action Copy to
Info Copy to

Rec'd in NASA

Suspense Date
Prepare Reply for
Signature of

August 19, 1976

ORIGINAL PAGE IS OF POOR QUALITY

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters
Code A
Washington, D.C. 20546

Dear Mr. Fletcher:

The South Dakota State Planning Bureau has been involved in the analysis and application of Landsat Data for slightly over two years. During this period, we have found satellite data to be timely, useful, and extremely valuable. The synoptic, repetitive coverage of Landsat has helped bring the rich resources of our sparsely settled state into perspective on many occasions. In almost all cases, information derived from Landsat photos and tapes would not have been gathered if we had been limited to traditional data gathering methods.

Landsat has served as the first and one of the most important data sources of the Land Resource Information System's (LRIS) land use and natural resource inventory. This program is in the process of completing its second statwide land use inventory. The first, a Level I analysis (Anderson system) was conducted using visual interpretation techniques on enhanced Landsat photography. The generalized land use pattern map produced (copy attached) has proven useful for overview and public information and education purposes. The second inventory, a Level II and partial Land III analysis, is being conducted using digital interpretation techniques and Landsat computer tapes. The detailed, synoptic information produced has proven useful on a wide variety of land use and natural resource planning and management tasks. It would not have been possible for us to complete either of these inventories if Landsat data had not been available.

In addition to land cover analysis, we have found surface water inventories developed from digital Landsat data to be extremely useful. And, if you will excuse the pun, we have hardly began to scratch the surface of the application of these water inventories. This data is incredibly easy to interpret, inexpensive to produce (less than 5¢ per square mile), and, for water bodies over a hectare, very accurate.

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Rec'd in Code E 8/26
Control Number E-5??

As stated earlier, very little of the information we have generated would not have been produced if we had been forced to rely on more traditional methods. Data gathering costs alone would have put the information far beyond our financial means, not to mention interpretation costs and numerous technical problems. The impact of this information on decision-making has been far reaching. Quantitative and qualitative data is available in a spacial format for the first time, considerably improving the rationality of decisions which were previously arrived at via intuition. Specific decisions which have been based on or aided by Landsat derived information range from the application of improved management techniques to control soil erosion in a particular drainage sub-basin to the granting of subsidies for stock dam construction on a particular section (square mile).

Given the lack of previous data, it is rather difficult to determine cost saving benefits of Landsat data. The value of merely having this new tool available is incalculable. As a point of reference, our level I analysis, completed in less than 6 months, cost less than $5000, exluding only postage costs for the distribution of over 3,000 copies. Using the highest altitude aircraft available commercially and the smallest scale imagery obtainable, data acquisition costs alone would have been well over $200,000.

Many agencies in South Dakota have benefited from the use of Landsat data. At the state level, in addition to the Planning Bureau, the Department of Game, Fish and Parks, the Department of Environmental Protection, and the Department of Natural Resources Development have all been involved in the analysis and application of remotely sensed satellite data. At the local level, the six Planning and Development Districts, Conservancy Districts, Resource Conservation and Development projects, and County Planning Commissions have been involved in the application of Landsat derived information.

The Landsat follow-on program, if approved by Congress and the President, and if implemented as planned, will significantly increase the capabilities of this already valuable data source. The improved resolution will make detailed urban analysis possible. We are currently relying on aircraft gathered data for the analyses, as the 1.1 acre resolution of the current Landsats is inadequate. The improved technology and the spectral responses of the thematic mapper will improve capabilities for vegetation analysis and crop identification. The improved data handling system will permit a throughput level which is conducive to near-real time applications.

Most importantly, implementation of the follow-on program will guarantee the continuity of satellite remotely sensed data. We have made large investments in the development of software and analysis techniques for the current Landsat series and are satisfied with the wisdom of this course. Data continuity will allow us to continue this development, thus improving current capabilities and working toward a smooth transition to the next generation of satellites. With a guarantee of data continuity, we will be able to redouble our efforts in the area of applications development. A strong foothold has been gained among planners and resource managers, but a regular supply of data is required to build upon this foundation. It is natural for people to be hesitant to try new ways of doing things. Uncertainty as to long range data availability has given some an excuse to procrostinate. The follow-on program should remove this final obstacle to operational applications.

To date, the State of South Dakota has invested $200,000 in the Planning Bureau's Landsat analysis program; $75,000 in the first year, and $125,000 in the second year. Assuming data availability, the third year funding level of $140,000 will be continued indefinitely, and perhaps even expanded as new applications are developed. The EROS Data Center has supplied technical assistance and about $20,000 worth of data products for the three year demonstration phase of our program. We have not received any other federal money for our program. We are hoping, however, to tap additional funding sources in the near future. Considering its small population (680,000), South Dakota has made significant investments in the development of applications of this new technology (50¢ per capita to date). These investments have been well placed.

South Dakota has established three means for supporting remote sensing technology. The first, which is discussed above, is the Land Resource Information System of the State Planning Bureau's Planning Information Assistance Program. This system provides analysis services and applications assistance to a wide variety of end users. The second is the Remote Sensing Institute of South Dakota State University. This institute serves primarily as a research center. To date, these institutional arrangements have proven to be satisfactory.

South Dakota is politically, institutionally, and technologically ready to move into the second generation of Landsat-type satellites. The first generation has been used extensively in both state and local government, and the success of these applications will encourage continued usage of this invaluable data source. Without the Landsat

follow-on program, rational resource management will be a much more difficult endeavor. Also, much of the hard earned progress with respect to data usage which has been possible, due mainly to Landsat, will be lost. Overall, rejection of the follow-on program would be most imprudent, and the State of South Dakota stands ready to offer any and all support to this vital project.

Sincerely,

Dan R. Bucks
Commissioner
STATE PLANNING BUREAU

DRB/PAT/pvk

ORIGINAL PAGE IS
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STATE OF TENNESSEE

RAY BLANTON
Governor

EXECUTIVE CHAMBER
Nashville 37219

April 12, 1976

Dr. James C. Fletcher
Administrator
National Aeronautics and
Space Administration
Washington, D. C. 20546

ORIGINAL PAGE IS
OF POOR QUALITY

Dear Dr. Fletcher:

Many state agencies have come to rely heavily on the LANDSAT satellite program for natural resources information. In conjunction with the NASA-Huntsville Marshall Space Flight Center, one agency is developing a system of environmental monitoring. In addition, LANDSAT data has been used to accurately map wetlands, identify major land use changes, and delineate strip mined land.

The Tennessee State Planning Office has worked closely with NASA-Huntsville on the application of remote sensing technology in a number of important areas of state government. These remote sensing programs have saved the state hundreds of man-hours in ground survey time.

The NASA LANDSAT program has been both useful and worthwhile. If you have any questions about our use of LANDSAT data, please contact Mr. John Wilson, Natural Resources Director, Tennessee State Planning Office (615) 741-1676.

Sincerely,

Ray Blanton

Ray Blanton

RB/dcm

Action Copy to EK
Info Copy to EO AI
EO

Rec'd in Code E 4/16
Control Number E-132
Suspense Date 4/23
Prepare Reply for
Signature of E

Action Copy to E
Info Copy to A, AD,
AA
ADA
AC

A-25060

Rec'd in NASA 4-15-76

Suspense Date 4-29-76
Prepare Reply for
Signature of E

TEXAS WATER RIGHTS COMMISSION

II-C(19-1)

STEPHEN F. AUSTIN STATE OFFICE BUILDING

May 11, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
Washington, D.C. 20546

ORIGINAL PAGE IS
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Dear Mr. Fletcher:

When the Inventory of Dams in Texas project was completed in 1974 resulting in the identification of 4240 dams each impounding 50 acre-feet or more of water, the use of ERTS imagery played a vital part in being able to accomplish this task in a timely manner. Aerial photographs are excellent for the location of water bodies and a great deal of detail about the dam and lake can be obtained, but aerial photographs are expensive, bulky and often not current.

With the construction of about 200 lakes per year in Texas a technique of updating the inventory of dams is needed and the Landsat follow-on program being prepared for proposal by NASA seems to be a way to accomplish this update. With the enhanced capabilities of Landsat follow-on smaller water bodies can be identified and areas of irrigated land detected.

In today's need for greater management of our water resources, the Commission needs an operational tool to identify new water impoundments in order to assist in obtaining compliance with State law. The Landsat follow-on program should be able to supply an extremely useful tool.

Sincerely yours,

TEXAS WATER RIGHTS COMMISSION

Robert E. Schneider
Executive Director

cc: Mr. Russell L. Schweickart

STATE OF UTAH
OFFICE OF THE GOVERNOR
SALT LAKE CITY

CALVIN L. RAMPTON
GOVERNOR

July 7, 1976

Action Copy to
Info Copy to
A 27203
Rec'd in NASA
Suspense Date
Prepare Reply for
Signature of

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters - Code A
Washington, D.C. 20546

Dear Jim:

I am writing to convey the endorsement of the states comprising the Federation of Rocky Mountain States for NASA's proposed LANDSAT follow-on program.

The Federation currently has underway a well-coordinated NASA-funded LANDSAT project using a digital satellite and ground-source data to conduct land use analysis. This new approach to acquiring and analyzing land use data provides planners in the region an inexpensive and objective source of data for developing a regional land use inventory.

The proposed capabilities of the LANDSAT follow-on program would provide additional benefits through increased amounts of information supplied in more varied and usable form and on a continuing basis. The vast expanses of this Rocky Mountain Region unquestionably lend themselves to the use of remote sensing techology. The resolution of new problems facing this region as a result of the energy onslaught in the Rocky Mountain states requires the application of LANDSAT and its associated technologies.

Therefore, I am authorized by my colleagues in the Federation to indicate our desire to see the LANDSAT follow-on become a permanent part of the federal government's data collection efforts. This will allow our states the opportunity to continually utilize this information as a part of our planning and policy making process.

You will be pleased to know that our regions assessment of the LANDSAT program as one of the most significant achievements of the U.S. space program is concurred in by the National Governors' Conference which earlier this month adopted the enclosed resolution at our annual meeting.

Sincerely,

Calvin Rampton

Governor

Action Copy to EK
Info Copy to ER
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ED-M

7/23

Prepare reply for
Signature of

D.- 34

LANDSAT FOLLOW-ON PROGRAM

THE GOVERNORS ARE BECOMING INCREASINGLY AWARE OF THE SIGNIFICANCE AND IMPORTANCE OF THEIR TIMELY NATURAL RESOURCES MANAGEMENT DECISIONS. THESE DECISIONS ARE BECOMING INCREASINGLY COMPLEX AND DIFFICULT DUE TO SUCH FACTORS AS GROWING COMPETITIVE DEMAND FOR RESOURCES, DWINDLING AVAILABILITY OF KEY RESOURCES, INCREASED RATE OF RESOURCE UTILIZATION, THE EXPANDING REGIONAL NATURE OF DECISIONS AS WELL AS RESULTING IMPACTS, AND THE NECESSITY TO ACHIEVE THE DESIRED BALANCE BETWEEN ECONOMIC WELL-BEING AND ENVIRONMENTAL QUALITY.

STATE, REGIONAL AND LOCAL RESOURCE MANAGERS ARE INCREASINGLY LOOKING TO REMOTE SENSING TECHNIQUES, AND IN PARTICULAR THE LANDSAT PROGRAM, AS AN IMPORTANT NEW TECHNOLOGY THAT CAN MAKE A SIGNIFICANT CONTRIBUTION TO THE INFORMATION BASE REQUIRED FOR IMPROVED RESOURCES MANAGEMENT. THE IMPROVED AND TIMELY RESOURCE DECISIONS RESULTING FROM THE AVAILABILITY OF LANDSAT-GENERATED DATA HAVE IMMEASURABLE BENEFITS. THESE BENEFITS INCLUDE IMPROVED RESOURCE MANAGEMENT, MAINTENANCE OF ENVIRONMENTAL QUALITY, AND THE REDUCTION OF FUNDS AND RESOURCES WASTED AS A RESULT OF DELAY AND LITIGATION ASSOCIATED WITH UNRESOLVED LAND MANAGEMENT ISSUES.

THE GOVERNORS, THEREFORE, RESOLVE TO SUPPORT THE LANDSAT FOLLOW-ON PROGRAM IN ORDER TO ASSURE CONTINUED AND IMPROVED DATA FOR USE IN NATURAL RESOURCE DECISIONS BY THE STATES.

II-C(21-1)

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR
OLYMPIA

DANIEL J EVANS
GOVERNOR

July 26, 1976

Action Copy to EK
Info Copy to ER
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Rec'd 8/4
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A

Dr. James Fletcher
Administrator
National Aeronautics and Space
Administration
Washington, D.C. 20546

Dear Dr. Fletcher:

I understand that NASA is preparing for the development of LANDSAT Follow-On systems, which are to be advanced versions of the LANDSAT-B system now being used in the Pacific Northwest Regional Commission's Land Resources Inventory Demonstration Project. The expectation in the State of Washington is that LANDSAT Follow-On systems will provide a cost-effective and timely source of land cover data for use by state and local land resources management agencies.

The prospects for developing such data have been our prime motivation for entering into the Land Resources Inventory Demonstration Project with NASA and the Geological Survey.

The project is viewed as an important adjunct to conventional means of acquiring these data. In addition, state and federal legislation has given rise to new requirements for data that are beyond the capacity of conventional methods in terms of area coverage, time schedules, frequency of update, and cost.

While the LANDSAT demonstrations in the State of Washington are not yet complete, the results reported by the participating agencies are highly encouraging. Two examples reinforce our belief that LANDSAT Follow-On systems will have considerable utility for resource management activities:

1. LANDSAT data are being used in a multi-stage analysis to produce an inventory of some 10 million acres of forests in western Washington. The methods being tested have been perfected, and the success of this demonstration seems assured. The results will be used in our Forest Productivity Study, which encompasses all of the

ORIGINAL PAGE IS
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STATE OF WEST VIRGINIA
OFFICE OF THE GOVERNOR
CHARLESTON 25305

ARCH A. MOORE, JR.
GOVERNOR

June 22, 1975

The Honorable Thomas P. Salmon
Governor of Vermont
State of Vermont
Executive Department
Montpelier, Vermont 05602

Dear Tom:

Information and data gathered through the Landsat Follow-On Program would be an invaluable general assistance not only to all fifty states but various specific state activities in such matters as transportation, mining and reclamation, rec[illegible], planning and property assessment and taxation.

Analysis of present trends, projections of future needs and the various policies and decisions required for programs depend upon the validity of the information collected and the reliability of the system used for collection. "Landsat" answers a significant portion of this need and all of us should support the program and avail ourselves of this service.

West Virginia could use "Landsat" to assist in such other Federal programs as the Water Quality Management Program of planning of EPA-208, land use and housing planning of HUD-701, and economic development planning of EDA-302.

The State of West Virginia does, indeed, strongly support your position on the uses and value of "Landsat" data.

Sincerely,

Arch A. Moore, Jr.
Governor

AAMJr:zv

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(II-23-1)

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Anthony S. Earl
Secretary

BOX 450
MADISON, WISCONSIN 53701

July 21, 1976

IN REPLY REFER TO: 3200

Action Copy to EK
Info Copy to ER
E
EDM

Dr. James C. Fletcher, Administrator
Nation Aeronautics and Space Administration
Washington, DC 20546

ORIGINAL PAGE IS
OF POOR QUALITY

Rec'd in Code 7/27
Control Number E-451
Suspense Date 8/2
Prepare Reply for
Signature of E

Dear Dr. Fletcher:

NASA's LANDSAT program shows good promise for a classification of Wisconsin lakes by trophic level which is required by Section 314, PL 92-500. The Wisconsin Department of Natural Resources has been working with the University of Wisconsin to develop a system utilizing LANDSAT imagery for periodic monitoring of the somewhat over 10,000 lakes in the state that are named or have an area of at least 20 acres.

This general overview will help analyze trends in lake eutrophication on a State wide scale. Although, the technology is still being refined, it is approaching the implementation phase.

The reflectance from a lake as picked up by LANDSAT imagery can be subjected to densitometric analysis to provide numeric values relating to degree of eutrophication.

We envision, with LANDSAT tapes and a computorized system of data extraction, being able to classify most of the State's significant lakes at a total cost of about $15,000 - 20,000 or less than $5 per lake and being able to do the job in 2-3 months time. The numerical classification will provide a sound basis for detecting and reacting to changes in water quality. The comparative cost of investigating and sampling each lake in the field for changes in water quality would be many times greater and prohibitive insofar as manpower and funding are concerned.

This program, like many of the experimental technologies, must be used so that its full potential can be realized. Our Department supports NASA in its efforts to bring space age technology to earthly application.

Sincerely,
Bureau of Water Quality

Francis H. Schraufnagel

Francis H. Schraufnagel
Assistant Director
FHS:dg
cc: Russell L. Schweikart, Code EK
Stanley C. Freden, Chief, Missions Utilization Office
Code 902 - NASA/Goddard Space Flight Center

Action Copy to E
Info Copy to A, AD,
AA,
A-27338 ADA,
B
Rec'd in NASA 7-23-76
Suspense Date 8-9-76
Prepare Reply for
Signature of E

D. SUBSTATE ORGANIZATIONS

D-(1)-ATLANTA,
GEORGIA

CITY OF ATLANTA

CITY HALL / ATLANTA, GEORGIA 30303 / (404) 658-6433

LEON S. EPLAN
Commissioner
Department of Budget and Planning

II-D(1-1)

Action Copy to EK
Info Copy to ER
E
ED-14

Rec'd in Code E 6/30
Control Number
Suspense Date
Prepare Reply for
Signature of

June 23, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
Washington, D. C 20546

Dear Dr. Fletcher:

This letter is the City of Atlanta's formal statement of support for NASA's efforts to proceed with a prototype, operational Landsat Follow-on Program. Urban areas have received a low priority in past attempts at transferring this technology, but our initial experience suggests that it is very important for cities to have the opportunity to evaluate Landsat capabilities.

For the past year, Atlanta has been participating with four other Urban Technology System members in a Land Cover Analysis Project sponsored by GSFC Intralab and coordinated by Public Technology, Inc. The purpose of the Project is to demonstrate the utility of Landsat data in an urban planning context, and to determine whether the workable techniques for applying this technology can be transferred between local jurisdictions.

In the first phase of the Project, which was just completed, San Jose, California, was selected to work closely with the Intralab staff to develop in-house land cover analysis capability. Their activities were monitored by senior planning officials from each of

the other four agencies. It is hoped that in the second phase, extensive "hands-on" experience will be available to each of the participants through the ORSER Time Sharing System at Penn State University. While no specific uses have yet been developed through phase one, it was the unanimous opinion of the Applications Review Committee that there is a good probability of success in phase two. This would be particularly true with the improved resolution proposed by NASA for future satellites, since level of detail was the greatest area of concern for urban applications. Therefore, based on our experience to date, we do support a continued and improved system of earth resources satellites.

Sincerely yours,

Leon Eplan, Commissioner
Budget and Planning

LE/lp

cc: Mr. Jule Sugarman
Mr. Larry Madsen
Mr. Russell L. Schweickert

Action Copy to E
Info Copy to A, AD, AA, ADA,
A26612
Rec'd in NASA 6-28-76
Suspense Date NONE
Prepare Reply for
Signature of

COMMONWEALTH OF VIRGINIA
COUNTY OF HENRICO

E. A. BECK
COUNTY MANAGER

June 14, 1976

Action Copy to E
Info Copy to 1, ADA
AA
A-26463 AC
X
Rec'd in NASA 6-22-76
Suspense Date 7-8-76
Prepare Reply for Signature of E

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
Washington, D. C. 20546

Dear Dr. Fletcher:

Henrico County, Virginia has been involved for the past year or so in a remote sensing project in conjunction with NASA. More specifically, the project involves a land cover analysis of Henrico County derived from earth satellite images. The information obtained from this source has been used in exploring options that provide the County with opportunities to perform forward looking planning functions. The first phase of this project is drawing to a close. NASA has expressed the possibility of continuing the project if we determine that it has potential value for operational achievements in the future.

Based upon our experience with the project thus far, we feel that continued participation by the County would be valuable. The following items are examples of capabilities that are in the process of being developed:

1. Assessment of impact of urbanization on agricultural lands.

2. Identification of point and non-point water pollution sources.

3. Identification of direct and indirect air pollution sources.

4. Identification of existing and potential open spaces.

5. "Quick look" verification of land use data developed by other agencies such as the Richmond/Crater 208 consortium.

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Rec'd in Code E 6/24
Control Number E-363
Suspense Date 7/2

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It is also conceivable that many additional uses of the information and images generated from LANDSAT would be forthcoming as we refine our ability to interpret the data. Henrico County is committed to continued involvement in this project and anticipate the development of several useful applications of the satellite system information.

Very truly yours,

E. A. Beck

E. A. Beck

cc: Mr. Russell L. Schweickart

D. (3) KERN
COUNTY, CALIFORNIA

KERN COUNTY WATER AGENCY
4114 Arrow Street, P.O. Box 58
Bakersfield, California 93302

Action Copy to EK
Info Copy to ER
ED
ED-M
E
Rec'd in Code E 6/10
Control Number E-320
Suspense Date 6/18
Prepare Reply for
Signature of E

June 7, 1976

Dr. James C. Fletcher,
Administrator, NASA
Washington, D. C. 20546

Dear Dr. Fletcher:

The purpose of this letter is to strongly endorse the continuation and improvement of the LANDSAT series of research satellites. We are specifically interested in the use of high resolution satellite imagery for crop identification, perched water monitoring and salinity detection, as proposed by the Geography Remote Sensing Unit of the University of California at Santa Barbara.

There is presently a lack of economical conventional techniques and expertise for gathering such accurate and timely information. Alternative on-the-ground methods of mapping to identify and record such parameters are slow, expensive and of varying accuracies. Information now being produced by satellite imagery is valuable for effective hydrologic management in both the short and long term time framework. The value of repetitive measurements cannot be stressed enough.

LANDSAT imagery appears capable of meeting many of our research survey requirements; we look forward however to improved resolutions. As in the past, we continue to encourage research aimed towards the development of analysis techniques appropriate to our research surveys.

Yours very truly,

Stuart T. Pyle
Engineer-Manager

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Info Copy to
ADE
X
A-26176
Rec'd in NASA
Suspense Date
Prepare Reply for
Signature of

xc: Mr. Roger Arno
NASA Aims Research Center
Moffatt Field, CA 94035

D. (4) LOS
ANGELES, CA ,
COUNTY OF LA, CA.

NORMAN MURDOCH
Planning Director
EDGAR T. IRVINE
Deputy Director
JOSEPH K. KENNEDY
Deputy Director
ROBERT W. CHAVE
Deputy Director

COUNTY OF LOS ANGELES
DEPARTMENT OF REGIONAL PLANNING

320 West Temple Street
Los Angeles, California 90012
Telephone 974-6401

Action Copy to EK
Info Copy to ER
E
ED-M
Rec'd in Code E 7/8
Control Number E-397
Suspense Date 7/16
Prepare Reply for
Signature of E

June 29, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
Washington, D. C. 20546

Dear Dr. Fletcher:

This letter will express our strong interest in, and support of, NASA's Thematic Mapper Development Project. Our organization, the Department of Regional Planning, provides basic planning services for all Los Angeles County. We have been a pioneer user of remote sensing information since our inception in the 1920's. More recently, we participated in the ERTS I/LANDSAT I Program during 1972 and 1973. As a result of our experience, we have a keen appreciation of the potentials of using remotely sensed data for urban and regional planning; and we are intensifying our use of remotely sensed data including satellite data. It is proving increasingly useful for land use and environmental surveys. We think that it has many other potential uses.

We would like to urge that the Thematic Mapper Project give increased attention to the development of capacity for determination of the quality and conditions of urban development, especially the identification of urban blight. We are also keenly interested in the development of the change detection potential of the project. It is very important to provide for widespread, timely dissemination of data from the project to user agencies at affordable costs. The Thematic Mapper Project, with its greater resolution and more diverse sensing capabilities, can help realize the great potential of remote sensing to contribute to the rapidly growing needs of planning for accurate, timely data.

Yours very truly,

DEPARTMENT OF REGIONAL PLANNING

Norman Murdoch

Norman Murdoch, Director of Planning

NM:JSM:lj

cc: Mr. Russel L. Schweikart
User Affairs, Code EK
NASA Headquarters

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Info Copy to AD, AA, ADA, B
A-26804
Rec'd in NASA 7-6-76
Suspense Date 7-20-76
Prepare Reply for
Signature of E

CITY OF LOS ANGELES

CALIFORNIA

TOM BRADLEY
MAYOR

DEPARTMENT OF CITY PLANNING
561 CITY HALL
LOS ANGELES. CALIF 90012

CALVIN S HAMILTON DIRECTOR

FRANK P LOMBARDI EXECUTIVE OFFICER

Action Copy to EK
Info Copy to ED
ED-M
ER

Rec'd in Code E 7/15
Control Number E-419
Suspense Date 7/23
Prepare Reply for Signature of E

July 8, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
Washington, D. C. 20546

REVIEW OF PROPOSED THEMATIC MAPPER (LANDSAT D) PRODUCTS

The Los Angeles City Planning Department is the principal physical planning and land use advisory agency to the City. As such it prepares a general plan (consisting of city-wide plans and community-specific plans), ordinances to implement the plans as well as reviewing for approval; zone changes, conditional land uses, and sub-division platt maps.

In these activities aerial photographs are used to provide planners with "snapshots" of an entire study area, conduct preliminary land use inventories, and verify field notes. Our direct use of aerial photo products has increased considerably over the past ten years and we anticipate the continued purchase of such products in the future to the limit of our budget.

In discussing Thematic Mapper products with Dr. Nevin Bryant of the Jet Propulsion Laboratory in Pasadena, we were again impressed with the potential satellite imagery has for urban applications. Depending on the geographic scale of our various study areas we can envision using LANDSAT D products as either primary or corollary sources of data. The potential for detecting urban land use changes and mapping those changes as well as existing land use seems particularly exciting.

However, our greatest interest in satellite products is not in the photography -- but in the generation of land use statistics for commonly used political units such as census tracts. The reporting of land use data by those geographic

units would allow us to interface satellite data directly with data we already use, such as assessor, census, building permits, electric meters, police, education and fire.

Most importantly, we would like to encourage NASA to seek to minimize the considerable distance that seems to exist between it and users such as ourselves. For satellite data to become more widely used we believe that a product delivery system such as those in use by the Bureau of the Census and U.S. Geological Survey must be developed by NASA. In any case we wish you continued success in your technology transfer efforts which we view as being of increasing direct benefit to mankind.

CALVIN S. HAMILTON
Director of Planning

Action Copy to E
Info Copy to A, AD, AA, ADA, B
A-27043
Rec'd in NASA 7-13-76
Suspense Date 7-28-76
Prepare Reply for Signature of E

CSH:chp

cc Mr. Russel L. Schweikart
User Affairs, Code EK
NASA Headquarters, Code A
Washington, D. C. 20546

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CITY OF LOS ANGELES
CALIFORNIA

ROBERT E. JOYCE
DIRECTOR
JULES MERSEL, MGR
DATA ANALYSIS DIVISION
CHARLES DRESCHER, MGR.
PROGRAM DEVELOPMENT DIVISION
DANIEL J. O CONNOR MGR.
ADMINISTRATIVE SERVICES DIVISION

TOM BRADLEY
MAYOR

OFFICE OF THE MAYOR
COMMUNITY ANALYSIS BUREAU
CITY HALL EAST
200 N. MAIN STREET ROOM 1110
LOS ANGELES, CALIFORNIA 90012
TELEPHONE 485 2952

July 2, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
Washington, D.C. 20546

Dear Dr. Fletcher:

The Community Analysis Bureau has been following the development of remote sensing capabilities from orbital spacecraft with great interest. Our program currently uses large scale, color infrared aerial photographs in the acquisition of data on neighborhood quality within the City of Los Angeles. We have long been interested in supplementing this source with automated data files acquired from spacecraft.

The increased resolution capability of LAND SAT sensors and the automated interpretation and coding of land use data to census tracts and other geographic units are quite useful in Bureau applications of remote sensing data. The acquisition of comprehensive, timely land use information for our data base appears to be the primary initial application of thematic mapper. We look forward in the future to even further improvements in resolution and computer applications to acquire still more detailed information on the urban environment.

Very truly yours,

Robert E. Joyce
Director

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REJ:bgp

Action Copy to EK
Info Copy to ED
ED-11
ER

Rec'd in Code E 7/19
Control No. E-429
Suspense Date 7/26
Prepare Reply for
Signature of E

Action Copy to E
Info Copy to A, AE
AA
ALA
B
A-27109
Rec'd in NASA 7-15-76

Suspense Date 7-30-76
Prepare Reply for
Signature of E

[illegible] CITY COORDINATOR [illegible]

[illegible] 348 2[illegible]

[illegible] 34[illegible]

[illegible] 343 [illegible]

[illegible] [illegible]

[illegible] 348 [illegible]

minneapolis

city of lakes

July 9, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
Washington, D.C. 20546

Dear Dr. Fletcher:

The City of Minneapolis, as a member of the Applications Review Committee of the the LANDSAT Urban Demonstration Project, believes that the concept of LANDSAT-generated data and its associated technology has great potential use in urban planning. However, we feel that the potential will not be fully realized without the stimulus of [illegible] LANDSAT continuation project. Therefore, I want to express my support of the proposed LANDSAT follow-on program.

Sincerely,

Thomas A. Thompson

Thomas A. Thompson
City Coordinator

cc: Mr. Russell L. Schweickart

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CITY OF NEW ORLEANS

OFFICE OF THE MAYOR

MOON LANDRIEU
MAYOR

July 6, 1976

Action Copy to E
Info Copy to A, ADL
AB1
ADA
B
A-26989
Rec'd in NASA 7-12-76
Suspense Date 7-27-76
Prepare Reply for
Signature of E

Dr. James C. Fletcher,
Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

During the past several years, the City of New Orleans has become increasingly aware of the potential benefit of NASA technology on problems faced by America's cities today.

We have designated our own Technology Transfer Officer. In addition, the Director of the City Planning Commission is responsible for coordinating applications of remote sensing and data systems within city government. The City has used or is evaluating for use a long series of products and techniques derived from your programs. We have constant coordination with your intergovernmental representative at the Regional Planning Commission.

For several years members of my staff have indicated that potential uses of satellite and aerial photography may yield practical results that would apply to most urban areas of the country. We have participated in experiments which have demonstrated several potential applications.

My personal experience in the U. S. Conference of Mayors indicates certain common problems from city to city. Some of these may be approached with developing technology.

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ER
Rec'd in Code E 7/14/76
Control Number E-415
Suspense Date 7/21
Prepare Reply for
Signature of E

I would urge you to continue your efforts to substantially improve the next Landsat satellites, associated data systems for urban use, and your technology transfer efforts with local governments.

Moon Landrieu
Mayor

ML:vl

CITY OF NEW ORLEANS

PRIDE BUILDS
NEW ORLEANS
MOON LANDRIEU
MAYOR

July 6, 1976

Action Copy to E
Info Copy to A, AD,
AA,
ADA,
B
A-26991
Rec'd in NASA 7-12-76

Suspense Date 7-27-76
Prepare Reply for
Signature of E

Dr. James C. Fletcher,
Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

I understand that the follow-on Landsat spacecraft are currently in the preliminary design stage, and you are considering an operational, not experimental system. As Vice Chairman of the Urban Consortium (a national organization composed of the thirty-three largest urban cities and counties) and as Director of a planning commission for a major city, I would encourage you to pursue this project and get the system working at the earliest possible date.

Many of us in the major cities have been reluctant to commit ourselves to use of satellite-derived data for our own use because the resolutions were too poor and the data source might quit functioning at any time. Additional hesitation on our part was caused by the absence of methods to merge the NASA data with our more conventional urban data systems. Each of these points appears to have a near term solution.

The commitment to an operational system will prevent the loss of the data source. Once familiar with the specific capabilities beyond early experiments, more urban areas will be inclined to use it.

Projects at your Jet Propulsion Laboratory and Marshall Space Flight Center show great promise for combining conventional and NASA data in a common digital data system. As they are currently planned, the operating cost of the final system may be sufficiently economical to receive widespread use throughout the country.

As the next satellite is still being designed, I recommend resolutions between three and twenty feet for urban areas. These resolutions would only be needed once or twice each year on cloud free days over only the urbanized areas. To do it more often would overwhelm both NASA and the cities with data bulks and densities for which we cannot currently envision a practical use.

In anticipation of the improved systems, we have made a major commitment to establish a sound base of data to take advantage of current and future Landsats and their associated systems. We are cooperating with the other local governments in the metropolitan area in a major parcel-by-parcel land use survey. The overall survey is fifty percent complete and the remaining half should be finished within the next two years. We felt this base line to be necessary because urban "signature analysis" does not appear to be fully developed. Urban changes are obvious to us in the most rudimentary Landsat photography. It is our considered opinion that urban changes from month to month from a satellite, measured against a known base of data date, and verfied by a small survey staff may be the cheapest method for keeping our land use up-to-date and accurate. When combined in a common digital system with our conventional data sources, we would have an extremely powerful tool for urban area governments. With other local governments, we have increased our staff skills and personnel to complement NASA skills in joint projects.

We look forward to continued work with your personnel on technology applications of current and future joint programs.

Harold R. Katner
Director/Secretary

HRK:vl

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A.26997
Rec'd in Code E 7/14/76
Control Number E-414
Suspense Date 7/31/76
Prepare Reply for E

PLANNING
COMMISSION,
LOUISIANA

REGIONAL PLANNING COMMISSION
JEFFERSON • ORLEANS
ST. BERNARD • ST. TAMMANY
PARISHES

May 27, 1976

Dr. James C. Fletcher
Administrator
NASA
Washington, D. C. 20546

Dear Dr. Fletcher:

Since 1970 the Regional Planning Commission has worked with NASA and NASA Technology in an effort to improve the methods for local and sub-state planning.

As an integral part of this activity we have utilized photography from NASA aircraft and spacecraft in both experimental and product-oriented efforts of this Commission. We have just completed a basic land use study of St. Tammany Parish utilizing products from LANDSAT, Skylab, NASA Aircraft and ground checks. Jefferson Parish completed a Natural Resources Inventory using LANDSAT and Aerial Images in January of 1975 with local funding. Many of the other public and private agencies in South Louisiana have utilized NASA Remote Sensing data for a variety of individual reasons - from locating archaeological sites, experiments in mosquito control, to management of a major private wildlife preserve.

We recognize that the utilization of this technology is in its infancy and will need to be successfully merged with more conventional data sources to be most useful to state and local governments.

The follow-on LANDSAT Satellite and the continuation of the NASA Aircraft program will go a long way towards introducing stability to the experimental efforts we have made in improving planning technology. As the next LANDSAT is still in the design stage, we would urge you to develop the minimum capability of 3 to 9 meters resolution for urban areas and 10 to 20 meters for rural areas. A "zoom" capability might be used over urban areas only when they are relatively cloud-free without an overwhelming data processing problem.

We would urge the continued development of both this capability and the auxiliary capacity of programs to use it successfully in local and state government.

Sincerely,

REGIONAL PLANNING COMMISSION

Charles F. O'Doniel Jr.

CHARLES F. O'DONIEL, JR.
DIRECTOR

CFO/vo

Action Copy to E
Info Copy to A
AA
ADA
AC-X
A-26043
Rec'd in NASA 6-1-76
Suspense Date 6-15-76
Prepare Reply for
Signature of E

Action Copy to ER
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D. (8)
SOUTHWESTERN
ILLINOIS PLANNING
COMMISSION

II-D(8-1)

SOUTHWESTERN ILLINOIS
metropolitan and regional
PLANNING COMMISSION

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203 West Main Street ☆ Collinsville, Illinois 62234 ☆ (618) 344-4250

June 18, 1976

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
400 Maryland Avenue, SW
Washington, DC 20546

Dear Dr. Fletcher:

The Southwestern Illinois Metropolitan and Regional Planning Commission takes this opportunity to lend its support to NASA for the proposed LANDSAT follow-on program.

The Southwestern Illinois Metropolitan and Regional Planning Commission (SIMAPC) is chartered by the Illinois State Legislature to prepare and coordinate development planning, serve as a research agency for local governments, provide technical assistance to local governments, and disseminate information to the public. As one means to fulfill our responsibilities we are turning to LANDSAT multispectral remote sensing as one tool to provide the data necessary for the decision-making processes.

Our purpose of using LANDSAT is to inventory and monitor the land cover. Using the LANDSAT inventory as input, our professional staff will develop plans to guide the development of our region through the year 2000, directed to improve the quality of our streams and rivers and provide local governments with the information required for logical community action regarding development policies.

With the availability of LANDSAT data, we know from experience that our inventory and analysis cost can be significantly reduced. Because our region is a part of the St. Louis Metropolitan Area, our need for more frequent monitoring is increasing beyond the frequency that other Federal agencies (i.e., U.S.G.S., U.S.D.A.) can provide. Therefore, without continuing the earth observations from LANDSAT we expect to incur increased costs with less efficient and timely data.

SIMAPC, as stated previously, was organized to serve local units of government. Serving those local units properly includes providing

endless data to regional, state and federal agencies. We are currently providing information, both primary and secondary, to a great number of other agencies including:

> Environmental Protection Agency
> Illinois Environmental Protection Agency
> Housing and Urban Development
> Illinois Surface Drainage Program
> Energy Resource and Development Agency
> Illinois Department of Local Government Affairs
> East-West Gateway Coordinating Council
> Illinois Department of Transportation
> and others

The LANDSAT follow-on represents many new potential applications. With the additional thermal I.R. band and 30 meter resolution, we hope to see increased accuracy of land cover inventories, monitoring of air and water quality, and better determination of our natural resource supplies.

Upon wider acceptance and the further moves toward the "operational status" of LANDSAT, many of us are taking this capability for granted. Now, even to suspect that LANDSAT is not here to stay is inconceivable. Many agencies throughout the country are beginning to accept this space technology as an everyday practice and to rely upon its availability to solve many complex land use issues.

Currently, we have proposals under consideration to monitor, over an eight-year period, the land use changes and ramifications, created by major developments occurring within the region. If indeed the LANDSAT follow-on is not funded and placed in orbit, we will then be unable to meet those project responsibilities as efficiently as we might otherwise.

For the first time, a medium of space technology can be used at the local and regional level. For the first time, we can identify and realize direct cost savings from space technology. And, for the first time, the average citizen can use this technology directly to affect decisions affecting him.

LANDSAT, with the inevitable progression of technology, should unquestionably be a standard public service. LANDSAT is a viable tool which can provide both natural and man-made resource information.

It is for these reasons, this Commission fully supports the LANDSAT follow-on program. Should there be any questions, please do not hesitate to contact us.

Sincerely,

Theadore H. Mikesell
Executive Director

THM/TH:hlb
cc: Mr. Russell Schweichart
Mr. A. Donald Goedeke
Mr. [illegible]

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City of Independence
MISSOURI 64050
103 NORTH MAIN STREET
TELEPHONE (816) 836-8300

June 9, 1976

Action Copy to EK
Info Copy to ER
ED
E
ED-M
Rec'd in Code E 6/15
Control Number E-329
Suspense Date 6/23
Prepare Reply for
Signature of E

Dr. James C. Fletcher
Administrator of NASA
NASA Headquarters, Code A
Washington, D. C. 20546

Dear Dr. Fletcher:

The City of Independence has been involved for the past several months in a research project whose purpose is to assess the feasibility of using LANDSAT data for urban planning purposes. Although the final outcome is still unclear, we are encouraged by the potential that we see, particularly if the resolution of future LANDSAT images is enhanced as planned.

Current land use planning is typically accomplished on a piecemeal basis. This approach does not always lead to the most desirable result. With the aid of LANDSAT imagery, we believe it will be possible to more effectively monitor urban growth and land use patterns, and to eliminate some of the problems caused by piecemeal planning. The capability of the LANDSAT imagery to provide a virtually continuous overview of the entire urban area will allow City planners to assume a more proactive role in zoning and other land use problems.

In our current project, we are working with four other local governments, Public Technology, Inc., Penn State University and NASA. The project involves the use of various computer programs designed for on-line analysis of LANDSAT data. The local governments involved will provide the necessary computer terminals and staff for investigating the potential benefits of the LANDSAT data and the analytical tools. Public Technology, Inc., Penn State University and NASA will provide technical and other support. At this time, it is difficult to predict the ultimate benefits of this project and of the LANDSAT program. However, we feel in both cases that the benefits can be significant. Accordingly, I strongly support the current LANDSAT program and

the steps being taken to increase its effectiveness through improvements in sensor resolution.

Sincerely,

Richard A. King
Mayor

RAK:vw

Action Copy to E
Info Copy to A, AA,
ADA,
AC, X
A-26291
Rec'd in NASA 6-14-76
Suspense Date 6-28-76
Prepare Reply for
Signature of E

APPENDIX III

PRIVATE INDUSTRY USER

REFERENCES

TABLE OF CONTENTS

A. BENNETT
STATEMENT

Energy Resources Exploration Petroleum (Bennett)

Petroleum exploration and production typically follows six stages of activity:

1.) Regional geologic reconniassance of large areas to recognize sedimentary basins and major structural features within the basin LANDSAT images compiled into mosaics have proven valuable to many companies for this exploration phase. In many cases major decisions on whether to acquire exploration concessions must be made on these preliminary analyses.

2.) Surface geologic mapping and sampling of outcrops. Enlarged LANDSAT images can aid in locating areas suitable for these studies. The savings in manpower and time can be appreciable, especially in areas where base maps are poor or lacking.

3.) Aerial magnetic surveys and ground-based gravity surveys are the initial geophysical reconnaissance. Trends of lineament and structures from LANDSAT interpretation of stage 1 can aid in locating and orienting these surveys to obtain optimum crossing of the structural pattern. Here again the base maps derived from LANDSAT can be valuable aids to the aircraft navigators and field party chiefs.

4.) Seismic surveys are made over promising anomalies located in the previous 3 stages. Trafficability and access information from the LANDSAT maps can save several days of crew time each month at a typical cost of $5,000 per day in isolated foreign areas.

5.) Drilling of prospects that have been targeted by activities 1 through 4.

6.) If the 1 to 20 odds against success have been overcome and an oil field discovered, the final stage is to product and transport the oil to market. Preliminary pipeline route studies can be made from LANDSAT

images and environmental impacts assessed.

The above stages deal with exploration on land. Increasingly exploration has been directed into offshore areas, many of which are in Arctic water subject to slo ice and icebergs. Repetitive coverage of LANDSAT can map ice distribution and movement to aid in assessing hazards to exploration and production in these harsh environments. A thermal IR band will provide imagery during the Arctic winter. Seismic exploration in shallow shelf seas is commonly hampered by unchartered underwater obstructions such as coral reefs and sand bars.

Band 4 of LANDSAT 1 and 2 is currently used to map these hazards; the water penetration band of LANDSAT Follow-On should be even more useful, if atmospheric scattering effects are not excessive. Natural oil seeps may be detectable on imagery as an aid to offshore exploration.

The above sequence of exploration stages and LANDSAT utilization are not hypothetical; a number of oil companies are known to procure and use large numbers of LANDSAT images and digital tapes. Chevran Overseas Petroleum reported at the NASA Symposium on Remote Sensing Applications in Houston on their use of LANDSAT in exploring and acquiring new concessions in Kenya (Miller, 1975). Wildcat wells are currently being drilled (Stage 5). In egypt Santa Fe Minerals correlated structural features interpreted from LANDSAT images with trends defined from gravity and aeromagnetic surveys (Berg and Gutman, 1976).

Sabins (1975) has addressed the common question of "How much oil has LANDSAT imagery discovered?" Those asking their question reveal a lack of understanding of oil exploration which involve many technical methods.

In the pre-LANDSAT era, it was difficult, if not impossible to credit a discovery well to a single technology. The time from beginning of exploration to drilling a well is commonly five years or more. LANDSAT imagery did not become widely available until the mid 1973's and industry then had to learn how to acquire, interpret, and utilize the imagery. On this time frame, the major petroleum benefits of LANDSAT are in the future. A final point is the concern over lack of oil industry publication describing their applications of LANDSAT. In addition to the Kenya and Egypt examples, Halbouty (1976) describes the correlation between circulor anamabies and salt dome structures on the U.S. Gulf Coast. Many industry interpretations of LANDSAT are not published because oil geologists are loath to endure the red tape of re-writing, drafting and editing material for publication. This is commonly a stronger restraing (contraints? restraint?) than company concerns over proprietary data.

The above applications are for LANDSAT 1 and 2. Many companies have already acquired their imagery of their areas of interest. This is shown by the fact that the oil industry has purchased the largest volume of data from the EROS Data Center. It is unlikely that they would acquire repeat coverage from future satellite unless there are significant improvements in spatial resolution and spectral coverage. There is a trend toward utilization of digital tapes for in-house processing on the computer facilities of most companies. Future satellites should provide CCT s that can be processed with existing software and hardware systems.

References

Bing and Gutman, 1976, Egypt application of LANDSAT: Proceedings of Pecora Symposium U.S. Geol. Survey in press

Miller, J.B., 1975, Application of LANDSAT to exploration in Kenya: NASA Earth Resoures survey symposium, Houston V.I

B CHEVRON OIL

Chevron

Chevron Oil Field Research Company
A Standard Oil Company of California Subsidiary
P.O. Box 446, La Habra, CA 90631, U.S.A.

July 23, 1976

James R. Baroffio
Vice President
Exploration Research Department

Dr. James C. Fletcher, Administrator
NASA Headquarters
Washington, D.C. 20546

Dear Dr. Fletcher:

We have been asked to evaluate the proposed Landsat Follow-On Program in terms of Chevron's needs and applications. Our evaluation is based on the attached list of proposed specifications that was provided by NASA. Chevron has used Landsat 1 and 2 images and digital tapes of domestic and foreign exploration areas for the following purposes:

1. Regional geologic mapping.

2. Trafficability and terrain analyses for surface access.

3. Bathymetry of shallow seas to aid marine seismic surveys.

4. Monitor sea ice movement in Arctic areas of exploration interest.

5. Mineral exploration.

Landsat 1 and 2 data have been very useful for these purposes, although no quantitative appraisal is possible.

We anticipate that Landsat 1, 2 and 3 will satisfy our needs for imagery acquired with the present MSS configuration. Once Chevron has obtained cloud-free coverage of the land areas, we will greatly curtail our ordering of MSS images. The proposed Landsat Follow-On with improved spatial resolution and spectral bands will initiate a new cycle of image acquisition and interpretation.

Specifically, the new mid-IR band (1.55 to 1.75 μm) of the Thematic Mapper should greatly aid in recognizing hydrothermally altered rocks in the vicinity of potential mineral deposits. The improved spatial resolution will improve the ability to resolve specific targets while retaining the broad image coverage that has been so useful. The proposed thermal IR band (10.4 to 12.5 μm)

will provide sea ice monitoring capability during periods of Arctic darkness. For geologic interpretation, our experience and that of other investigators indicates that thermal IR imagery must be acquired at night. Only experience will establish the applicability of this relatively low resolution thermal IR imagery.

Although not mentioned on the proposed Landsat Follow-On specifications, we believe that stereoscopic image coverage will be valuable. This is based on our work with the limited stereo sidelap from Landsat 1 and 2 that has minimal vertical exaggeration. We believe that complete stereo coverage of the earth's land areas with optimum vertical exaggeration would be valuable. Repeated coverage would not be necessary after cloud-free coverage of high quality images has been acquired.

Chevron has found Landsat 1 and 2 data to be very useful for various applications. We anticipate that the Landsat Follow-On capabilities discussed above will be of similar or greater operational usefulness.

Sincerely yours,

Original signed by
J. R. Baroffio
J. R. Baroffio
Vice President
Exploration Research Department

Attach: Landsat Follow-On
Specifications

cc: Mr. R. L. Schweickart (NASA Headquarters,
Washington, D.C.)-1+1

D

LANDSAT FOLLOW-ON PROPOSED SPECIFICATIONS

SCANNER CHARACTERISTICS

SPECTRAL BANDS (MICROMETERS)	MSS	TM
BLUE		0.45-0.5
GREEN	0.5-0.6	0.52-0.6
RED	0.6-0.7	0.63-0.69
NEAR IR	0.7-0.8	
NEAR IR		0.76-0.90
NEAR IR	0.8-1.1	
MID-IR		1.55-1.75
THERMAL IR	10.4-12.6	10.4-12.5

SPATIAL RESOLUTION: 30 METERS
120 METERS THERMAL IR

QUANTIZING LEVELS: 256 (8 bits)

SAMPLING FREQUENCY: 1.4* SAMPLES/IFOV

DATA RATE: 110 MB/S

SCENE: 180 x 180 KM

MISSION PARAMETERS

ORBIT (APOGEE): 705 KM, sun synchronous

LOCAL TIME AT DESCENDING NODE (EQUATORIAL CROSSING): 11:00AM

COVERAGE CYCLE DURATION: 9 DAYS

IMAGE & PROCESSING CHARACTERISTICS

INFORMATION PER IMAGE: $2(10^9)$ BITS

TOTAL IMAGES: 500**/DAY (ALL LAND MASSES PLUS COASTAL AREAS)

TOTAL INFORMATION: 10^{12} BITS/DAY

FACILITIES OBJECTIVE: NO BACKLOG IN PROCESSING AND ARCHIVING

* ASSUMING MODULATION TRANSFER FUNCTION SIMILAR TO PRESENT LANDSAT MULTISPECTRAL SCANNER

** CLOUDFREE

C. EXXON
PRODUCTION
RESEARCH COMPANY

EXXON PRODUCTION RESEARCH COMPANY
POST OFFICE BOX 2189 · HOUSTON, TEXAS 77001

BASIN EXPLORATION DIVISION
R T FETTERS
MANAGER

June 22,1976

Mrs. Barbara Williams
NASA Office of Applications
Code E-K
Washington, D. C. 20456

Dear Mrs. Williams:

This is a follow-up to your discussion last month with H. R. Hopkins and the EPR Satellite Imagery Group regarding the application and usefulness of LANDSAT imagery in exploration for hydrocarbons. We should point out that it is difficult to provide concise and direct answers to most of the questions on the questionnaire which you requested that we complete. It is particularly difficult to provide information on the cost effectiveness or savings realized from use of LANDSAT imagery. In general, satellite imagery has been viewed as an additional exploration tool and has not resulted in elimination of other conventional exploration methods normally used in such investigations.

To more fully explain our Company's position, we basically fulfill three functions for Exxon Corporation affiliates in application of satellite imagery for exploration purposes:

1) We maintain a Data Bank and expedite requests for LANDSAT, Skylab, and other types of remote sensing data for use by affiliate companies;

2) On request we conduct technical service investigations for affiliate companies, including interpretation of LANDSAT imagery; and

3) We are engaged in an active research program of testing and developing digital and optical image processing and interpretational techniques.

We have acquired worldwide LANDSAT mosaic coverage which has been used by us and our affiliate companies in regional studies. In general, the procedure in such studies is to combine all available geological and geophysical data for an area. Occasionally, interpretations will be made based solely on the LANDSAT imagery and combined with other regional information at a later date. Standard aerial photography is generally not included in a study, except for occasional detailed work.

Exxon Production Research Company acts only in a general consulting capacity to operating affiliate companies, and as such we have no way of estimated cost effectiveness or savings realized from application of LANDSAT imagery. We do, however, recommend areas that appear more prospective for oil and gas exploration as well as those areas that appear less favorable for hydrocarbon entrapment. Likewise, we identify regional and local structural trends which aid in outlining the most efficient and economical plans for seismic surveys of an area. The main point is that LANDSAT imagery is not a unique tool, but one of many exploration tools. LANDSAT imagery interpretations increase our knowledge and understanding of the geology of an area so that better decisions can be made in regard to application of more expensive exploration techniques.

We hope this information will assist you in preparing and presenting your case for the support of the LANDSAT Program. We consider LANDSAT one of the most important and significant projects undertaken by NASA. It has direct and immediate application in the search and development of our nation's natural resources. Implementation of proposed follow-on LANDSAT programs will significantly improve the system and allow even more direct application in the exploration for natural resources.

Should you have any other questions, or if we can be of additional assistance, please contact us.

Very truly yours,

R. T. FETTERS

By Marcus E. Milling
M. E. Milling

HRHopkins:bb

cc: J. B. Coffman

D. MICHEL T.
HALBOUTY

A26080

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June 1, 1976

Action Copy to E
Info Copy to A, AA, ADA, AC, X
A-26080
Rec'd in NASA 6-3-76
Response Date 6-17-76
Prepare Reply for Signature of E

Dr. James C. Fletcher, Administrator
NASA Headquarters
Washington, D. C. 20546

Dear Dr. Fletcher:

As you may know I am vitally interested in the Land Satellites Program. I have repeatedly and publicly stated that I consider the Landsat project as one of the most productive and significant missions ever conducted by NASA. In fact, I have further stated that it is one of the most important national initiatives ever conceived and implemented in our 200 years of existence.

Among the many contributions to human needs, the Landsat images have proven to be a new and constructive tool in mineral and petroleum exploration. The application of these data have already improved the nation's domestic mineral resource base and will continue to do so on a much larger scale provided the entire program is continued and implemented with new stages of properly equipped satellites to produce vital earth science data.

I trust that Congress will approve and appropriate funds to establish the Landsat project on a much longer program than is now scheduled.

If I may be of any assistance to you in any way, please do not hesitate to so advise.

Sincerely,

Michel T. Halbouty

Michel T. Halbouty

ORIGINAL PAGE IS
OF POOR QUALITY

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS BULLETIN

MAY 1976 VOLUME 60, NUMBER 5

Application of Landsat Imagery to Petroleum and Mineral Exploration

MICHEL T. HALBOUTY
Consulting Geologist and Petroleum Engineer
Independent Producer and Operator

Abstract: The Landsat (ERTS) project is the most significant mission ever flown by NASA. The use of Landsat imagery by the mineral and energy industries in the United States can improve the nation's domestic resource base in a shorter time and at more reasonable cost than would have been possible otherwise.

Properly interpreted information from Landsat images can save corporations millions of dollars in unnecessary exploration and development efforts and at the same time, provide geologic clues to the discovery of tremendous reserves. The more the Landsat data are used, the more innovations for their use will be established.

Landsat data have broad use in the minerals/fuel field including the following general applications.

1. Detection of large-scale geologic structures that previously were unknown and which may be significant with respect to the localization of hydrocarbons. Such features commonly are not recognizable on aerial photographs.

2. The possible detection of very subtle tonal anomalies that may represent alteration of the soils resulting from miniseeps of gas from hydrocarbon reservoirs.

3. The potential for detecting natural marine oil seeps with consequent improvement in efficiency of offshore exploration.

4. Detection on outcrops of important minerals and metals, especially in hostle environments.

5. The monitoring in Arctic areas of ice distribution and movement that may affect transport of materials, the cost of seismic exploration in sea ice areas, and the safety of exploration and production operations.

6. The monitoring of oil-field development and transport facilities, such as the Alaska pipeline, and an assessment of this development on the environment.

7. The potential for improved communication and decision making within petroleum companies.

Landsat imagery provides the explorationist a most rapid and inexpensive tool which could add immeasurably to his geologic knowledge.

Mobil Research and Development Corporation

RESEARCH DEPARTMENT
P O BOX 900
DALLAS, TEXAS 75221

ROBERT J WATSON
MANAGER
FIELD RESEARCH LABORATORY

July 26, 1976

Ms. Barbara Williams
NASA EK
Washington, D. C. 20546

Dear Ms. Williams:

As discussed in our recent telephone conversation, I offer the following comments as to our use of Landsat data.

Our principal use of the data has been for regional geological studies, particularly tectonic analyses. These studies have been in support of Mobil's world-wide exploration for both petroleum and other mineral deposits.

The applications have been fairly well balanced between North America and foreign areas, including Africa, the Middle East, and Far East.

We have examined shallow-water offshore areas for geological features.

In one instance, offshore Egypt, we did use Landsat imagery to determine shallow-water areas potentially hazardous to marine seismic surveys. In this case bathymetric charts were of pre-1900 vintage and of questionable reliability.

It is our observation that the application of Landsat data to petroleum and minerals exploration is increasing. We have both research and application objectives that rely on the continued availability of the data presently available and those scheduled to be acquired in the future.

Very truly yours,

Eugene L. Jones

Eugene L. Jones, Manager
Exploration Research

ELJ:ob

LANDSAT DATA CONTRIBUTIONS TO HYDROCARBON EXPLORATION IN FOREIGN REGIONS

BY

F. P. Bentz, Vice President, Santa Fe Minerals, Inc.
3131 Turtle Creek Blvd., Dallas, Texas 75219

AND

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505 So. Main Street, P. O. Box 1401, Orange, California 92668

TABLE OF CONTENTS

LIST OF FIGURES

Figure

ABSTRACT

Foreign exploration frequently requires that large areas of relatively unexplored territory be evaluated in the most expeditious and informative manner. The selection of areas with the greatest potential would normally start with the least expensive reconnaissance tools like photogeology, field work and aeromagnetics before proceeding to the more costly and possibly more definitive techniques such as gravity, seismic and eventually drilling. In many areas, however, this ideal sequence of evaluation can no longer be followed due to shortened exploration periods and other restrictive government regulations.

Santa Fe Minerals' past experience with LANDSAT has proved that the ready accessibility of multispectral imagery provides for quick and inexpensive reconnaissance of foreign exploration areas. Firstly, it allows the construction of geographic base maps which are often more accurate than any existing maps. Secondly, LANDSAT imagery is an invaluable source of geologic information; if used in conjunction with existing published data it will, in most cases, improve the accuracy of geologic mapping and understanding of an area. In addition, it has been found that the imagery complements and aids in the interpretation of aeromagnetic and gravity data; this relationship is reciprocal.

Santa Fe Minerals has successfully experimented with LANDSAT multispectral imagery and, as a consequence, now routinely integrates LANDSAT data into its exploration efforts.

Exploratory work in Egypt and Yemen serves to illustrate how LANDSAT imagery is used; some results are presented.

INTRODUCTION

The purpose of this paper is to present some of the major contributions of LANDSAT data to Santa Fe Mineral's hydrocarbon exploration in foreign areas.

Explorationists find themselves today in a highy competitive environment, complicated by shortening exploration periods and increasingly restrictive governmental regulations. For these reasons it is not always possible to follow a normal foreign exploration sequence, which is essentially a process of isolating and identifying targets with hydrocarbon potential from a large and relatively unexplored area. This process usually begins with reconnaissance tools such as aeromagnetometry, SLAR, and photo-geology and proceeds to the more costly and time consuming (but hopefully more definitive) methods such as seismic surveys and drilling. LANDSAT data, because of their ready accessibility, help significantly in shortening the early reconnaissance stage of operations. In addition, LANDSAT imagery is, because of its low cost per unit area, one of the best data buys the explorationist can make.

LANDSAT has proven itself to be a valuable source of geological information. It has invariably improved the contact and spatial relationships of outcrops in poorly or sparsely mapped areas. The mapping of linears helps to define a structural fabric or framework in the exploration area. This fabric is often indistinct or invisibl at the surface but, nonetheless, strongly influences hydrocarbon accumulations. With few exceptions the pattern of linears is highly

regular and can often be related to stress analysis. Subtle color and tonal anomalies have been observed which are believed to be of significant exploration importance.

Significant relationships between gravity and magnetic data and alignments or trends have been observed in LANDSAT imagery. Initial conclusion suggest that the basement and inter-sedimentary structures which are routinely interpreted from the potential field data, have greater (but subtle) surface expressions than we had previously anticipated.

Because it has been successful, LANDSAT data is now routinely integrated into Santa Fe's foreign exploration programs. It aids in planning geophysical surveys and allows the creation of exploration base maps onto which the results of literature searches and available data can be posted; one is now able to begin the data acquisition and interpretation process almost immediately.

Exploratory work in Egypt and Yemen will serve to illustrate some of the contributions that LANDSAT data has made to our foreign exploration program. The choice of Egypt and Yemen was made because they essentially represent opposite ends of the information spectrum available to the explorationist.

The permit area in Egypt has well-exposed surface geology, portrayed on relatively detailed geologic maps. In addition, there are subsurface data available from nearby wildcat tests as well as Bouguer gravity and residual magnetic intensity maps. In contrast, the onshore exploration area in Yemen is covered with alluvium. There is no well data available from the five dry holes previously drilled there in the early 1960's, nor is there an adequate or reliable geological map of the area. Despite the current interest

there is little in the published literature concerning the onshore geophysics of the Yemen Arab Republic.

LANDSAT DATA CONTRIBUTIONS TO HYDROCARBON EXPLORATION IN EGYPT

The East Cairo concession straddles the Cairo to Suez highway and encompasses about one million acres (Figure 1). It is bounded on the east by the Great Bitter Lake and on the west by the Damietta Branch of the Nile River where it comprises a small portion of the highly cultivated and densely populated Nile Delta. The rest of the concession area consists of gently rolling gravel desert, bounded to the south by east-west trending escarpments of Eocene limestone.

These physibgraphic provinces are an expression of the geology, as shown on Figure 2, a geologic sketch map reproduced with permission from Saids' The Geology of Egypt (Said, 1962). The 30th parallel (crossing the map in the center) forms the southern boundary of Santa Fe's permit.

The bulk of the escarpment-forming Eocene limestones lie south of the 30th parallel. Most of the concession is characterized by east-west trending outcrops of Oligocene to recent age, with Eocene rocks showing only in a few anticlines. Exposures of Cretaceous sediments are reported from Gebel Shabrawet overlooking Great Bitter Lake. The east-west trending outcrop pattern is indicative of the apparent folding axes; the main pattern of faulting, shown on the map, has a northwest-southeast direction.

Figure 3 is a LANDSAT mosaic which encompasses a much larger area than the geologic map. One can orient oneself by Cairo at the neck of the delta in the west; the Suez Canal and Great Bitter Lake on the east, and the Mokkattam limestone escarpment forming the southern concession boundary to the south.

Quite a number of geologic features shown on Said's map can be readily indentified on the LANDSAT image; for instance, the Eocene horst of Gebel Oweibid. Interestingly, there are many other geologic patterns which are more visible on the LANDSAT imagery than on the surface geologic map. As an example, note the almost circular syncline southwest of Gebel Shabraweth which is rather inadequately represented on the surface map.

A great number of major and minor linears can readily be observed on the LANDSAT mosaic; as shown in Figure 4. Close scrutiny reveals that these linears represent a limited number of statistical trends.

A presentation in the form of a star diagram not only enhances their regularity but also shows that they are intersecting each other at angles of approximately 15°, 30°, and 60° (Figure 5). These are the expected angles for shear sets of a strain ellipse and they can also be related to Moody & Hill's wrench fault tectonic scheme (Figure 6) first published about twenty years ago (Moody and Hill, 1956).

This does not imply that the Cairo-Suez area is governed entirely by wrench-faults. In an area that lies at the junction of several important crustal plate boundaries which separate the African continent from the Mediterranean crust to the north and from the Sinai and Arabian blocks to the east, one can expect that divergent movements of these crustal blocks created a forceful stress system. This was likely relieved by a complex pattern of shear zones, compressional features and tensional rifts.

The major structural units are illustrated in a simplified manner in a regional tectonic sketch (Figure 7).

The Gulf of Suez-Red Sea system is one of the most outstanding features in this area. It likely consists of a combination of tensional rifting and strike-slip movements (left lateral wrench faults). Initial block faulting occurred towards the end of Oligocene time and was associated with widespread volcanism.

If sea floor spreading is indeed a factor in the later history of this area, it was restricted to the Red Sea proper and did not penetrate the Gulf of Suez.

The Gulf of Aqaba - Dead Sea sheer zone is equally impressive in its magnitude. It is probably along this left lateral wrench fault that any plate movement caused by Red Sea spreading occurred.

A distinct N 50° W trend occurs at a 15° angle to the N 35° W Gulf of Suez - Red Sea trend. Said combines the two trends under the name "Erythrean or African faulting"; and indeed, the shorelines of the Gulf of Suez and the Red Sea are controlled by segments of both of these two trends (Said, 1962, P.33). The N 50° W direction appears to be much older since it is expressed in shears within the Precambrian shield (Abdel-Gawad, 1969). In addition, the N 50° W direction was certainly rejuvenated in more recent times causing some of the more prominent right lateral shears in our area of interest.

The north-south or "East African" trend is described by Said as "the old grain of Egypt" (Said, 1962, P.32), yet it still seems to have played an important role in more recent geologic events, being responsible for deflections of the Gulf of Suez shorelines and of the Nile River.

An east-west trend related to the "Tethyan" direction is prominent in Sinai and crosses the concession area in several places. At Gebel Oweibid it can be interpreted as a right lateral wrench fault based on the outcrop configuration shown on the geologic map.

A major folding axis described as the Gebel Maghara-Abu Roash line crosses our area in a N 70° E direction, at right angles to the primary stress oriented at about N 20° W. This primary fold axis is not obvious from the geologic surface map of our concession area; however, the magnetic intensity and the Bouguer gravity map do reflect this structural orientation.

Considering the regional aspects of this main axis, one can discern a southwesterly plunge from the Jurassic outcrops at Gebel Maghara in the Sinai to the Middle Cretaceous outcrops at Gebel Shabrawet near the Great Bitter Lake and to the Lower Cretaceous and Jurassic encountered 2,000 feet below the surface in the Abu Roash wells.

At right angles to the primary stress lie also the direction of greatest tension which could, at least in part, be responsible for the rifting of the Gulf of Suez. And while a number of the mapped lineaments are probably related to strike-slip movements, others are associated with block faulting and tilting. It is believed that the major movement along the Gulf of Suez trend was a vertical displacement along normal faults resulting in tilted fault blocks. This can be illustrated by the uplifted Middle Cretaceous sediments at Gebel Shabrawet west of the Great Bitter Lake. A similar uplift along the same direction of faulting probably occurred at Abu Roash west of the Nile Valley near Cairo. This set of block faults would result in a steepening of the southwestward axial plunge across the area.

Evidence for horizontal displacements is illustrated by a set of drag folds that forms a distinctive pattern in the center of the concession area.

In the course of our work, we have observed a surprising correspondence between gravity and magnetic data and LANDSAT imagery. It usually is in the form of close associations of linears and lineaments with high gradients and magnetic accidents (Figure 8). The magnetic anomalies which are essentially reflecting the configuration of the magnetic basement dramatically confirm the substance of the N70E regional trend that was first observed on the LANDSAT imagery. Please note the departure of the field from this trend in the south-central portion of the permit area. We have interpreted this as the reorientation of the basement along a major left lateral strike slip fault seen on LANDSAT data. This is an excellent example of how the potential field data and the LANDSAT imagery compliment each other to arrive at a unified and consistent geological picture.

The correspondence of the Bouguer gravity anomalies (Figure 9) with the surface geology (Figure 2) is quite good. Note the roughly east-west alignments of gravity highs over the folded and faulted Oligocene sediments in the north and observe that a broad, regional trend of N70E is disturbed by high frequency anomalies associated with contacts and structures, particularly in the center of the area. In the west, where there is a total absence of geologic outcrops due to the vegetative cover of the Nile Delta, we have a broad, elongated gravity low which trends north-south.

The LANDSAT interpretation highlights the contact and fault relationship inherent in the gravity data as well as the regional N70E trend which we feel is quite important to hydrocarbon accumulations east of the Nile Delta. Please observe that jogs in the course of the Nile are associated with flexures in the gravity anomalies and the extensions of lineaments mapped outside the Delta. We conclude that not only is the present course of the Nile largely fault controlled but that these faults influenced the development of a gorge of Grand Canyon proportions which formed at the end of Miocene. This gigantic 10,000 foot deep erosion channel (discovered by Santa Fe's seismic reflection work) helps to explain the conspicuous north-south gravity low mentioned above.

LANDSAT DATA CONTRIBUTIONS TO HYDROCARBON EXPLORATION IN YEMEN

The Yemen Arab Republic lies on the southwestern tip of the Arabian Peninsula (Figure 10). The area in which Santa Fe Minerals was interested encompasses, in total, more than 5.7 million acres of which close to 4 million acres are located onshore. A rather restricted exploration option of eight months required us to survey this vast area in the most expeditious and cost effective manner. For this purpose, an abbreviated exploration program was undertaken consisting of an offshore seismic survey combined with marine gravity and magnetics. Over the onshore portion an aeromagnetic survey and LANDSAT interpretations were conducted.

The LANDSAT mosaic (Figure 11) will give the reader an indication of the nature and quality of the data as well as a feel for some of the interpretation problems that were encountered.

The Tihama Plain extends 400 kilometers north to south along the Red Sea Coast. This coastal plain gently dips to the west from a mountain front which dramatically rises to heights of over eight thousand feet. Although faulting, fracturing and jointing are clearly visible in the mountains, at first glance there appeared to be an almost total lack of these features in the plain due to the thick alluvial cover. On closer inspection, however, it was observed that despite the lack of outcrops in the Tihama Plain there are a profusion of subtle color or tonal streaks as well as circular anomalies visible from orbit which are totally indistinct either on the ground or in the aerial photos (Figure 12).

Lineaments in the mountains define a structural fabric which is relatable to the stresses that this area has been subjected to as a result of regional upwarp or arching during the Oligocene, and rifting during the early and middle Miocene. Linears in the coastal plain echo the structural fabric of the mountains lending support to the possibility that these color and tonal anomalies reflect in some way the configuration of the subsurface, specifically fault blocks and attendant structures.

Subtle circular anomalies are observed in the LANDSAT images and appear to be concentrated north of 14° 30'. Salt is being mined from outcrops of Miocene age which have surfaced along the Red Sea Coast, particularly around Salit (El Shazly, 1967). It is also understood that an oil company had drilled several of its wells on gravity lows, suggesting that salt domes were its exploration targets (Priviledged Communication 1975). The

Aeromagnetic Survey revealed that no magnetic anomalies are directly associated with these features. As a consequence, it is confidently felt that some of the circular anomalies reflect salt diapirs. Their concentration above N14° 30' suggests a thickening of the section in that area, strengthening the results of the aeromagnetic interpretation.

The subtle circular anomalies (such as those targeted on Figure 13) are best seen in band 7 images and in stretched false color composites. While most of the anomalies appear as breaks in the tonal pattern of the plain, some are associated with vegetation occurrences.

Of the five wells drilled by an oil operator in the early 1960's, three of them are located on circular anomalies (Figure 13). It is observed that all of the wells drilled on circular anomalies lie on the flanks rather than on top of structural basement highs as interpreted from the aeromagnetic data, further supporting the contention that these circular anomalies reflect the presence of numerous diapirs.

The color or tonal anomalies which we alluded to are highlighted in a portion of LANDSAT-1 Scene 1117-06562 (Figure 14). The streaks, trending southwesterly appear to be related to the onshore extension of faulting as interpreted from our offshore seismic program. We feel that these represent a reorientation of the drainage patterns as a consequence of southwest tilting of the section along these faults.

The alignment of northwesterly trending streaks suggests that they may be the expression of faulting parallel to the Red Sea rift axis. Stream offsets along one such tonal anomaly indicates approximately three kilometers of right lateral offset. The association with

earthquake epicenters (Fairhead et. al, 1969) further indicates that these streaks are the surface expressions of faulting (See Figure 12).

Compagnie General De Geophysique (CGG) flew a 4600 km aeromagnetic survey for this exploration effort in April of 1975. The results of this survey were very gratifying because they not only confirmed the results of the offshore work, but made many of the features seen in the LANDSAT imagery understandable in a structural context. A few of our observations may serve to illustrate this point.

A north northwest trending fault system (interpreted by CGG) parallels the mountain front and some of the linears observed within and at the foot of the mountains.

The extensions of some lineaments from the mountains onto the Tihama Plain coincide with high magnetic gradients not initially defined as faults. This aids in amplifying the interpreted fault pattern.

Conversely, magnetic events interpreted as basement faults coincide with stream courses emerging from the mountains, suggesting structural control of some of the drainage patterns.

The flanks and basinal axis of a three kilometer deep magnetic anomaly are reflected by surface linears.

Numerous other interrelationships between magnetic data and linears in the Tihama Plain assist in deciphering the structural development of the area.

It is of particular interest to note that LANDSAT observed linears are not solely related to fault and fracture patterns; but often reflect deepseated structural trends and a variety of geologic phenomena.

Considering its demonstrated versatility, low cost and ready access, LANDSAT imagery deserves to be applied to all integrated exploration efforts, foreign or domestic.

ACKNOWLEDGEMENTS

We wish to express our appreciation to Santa Fe International Corporation for encouraging us to prepare this paper. Our thanks to Dr. M. K. El Ayouty of EGPC for permitting us to present our findings in Egypt and to Elsevier Publishing Company for permission to reproduce Said's geologic map. We also thank Peter Coberly and Michael Wallace of Custom Color Labs in North Hollywood, California who produced our LANDSAT false color composites and Santa Fe's Art Department which produced the illustrations for this paper. Special appreciation is due to Dr. William A. Fischer and Donald Orr of the USGS EROS Program for inviting us to publicize our work with LANDSAT imagery.

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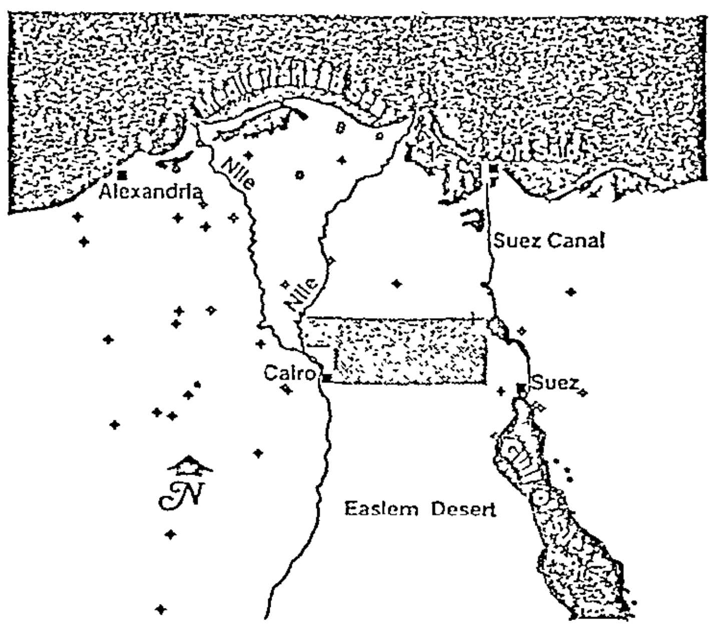


Figure 1. Index Map of Northern Africa showing Santa Fe Minerals, Inc. exploration area.

Geology of Cairo-Suez District, after Said

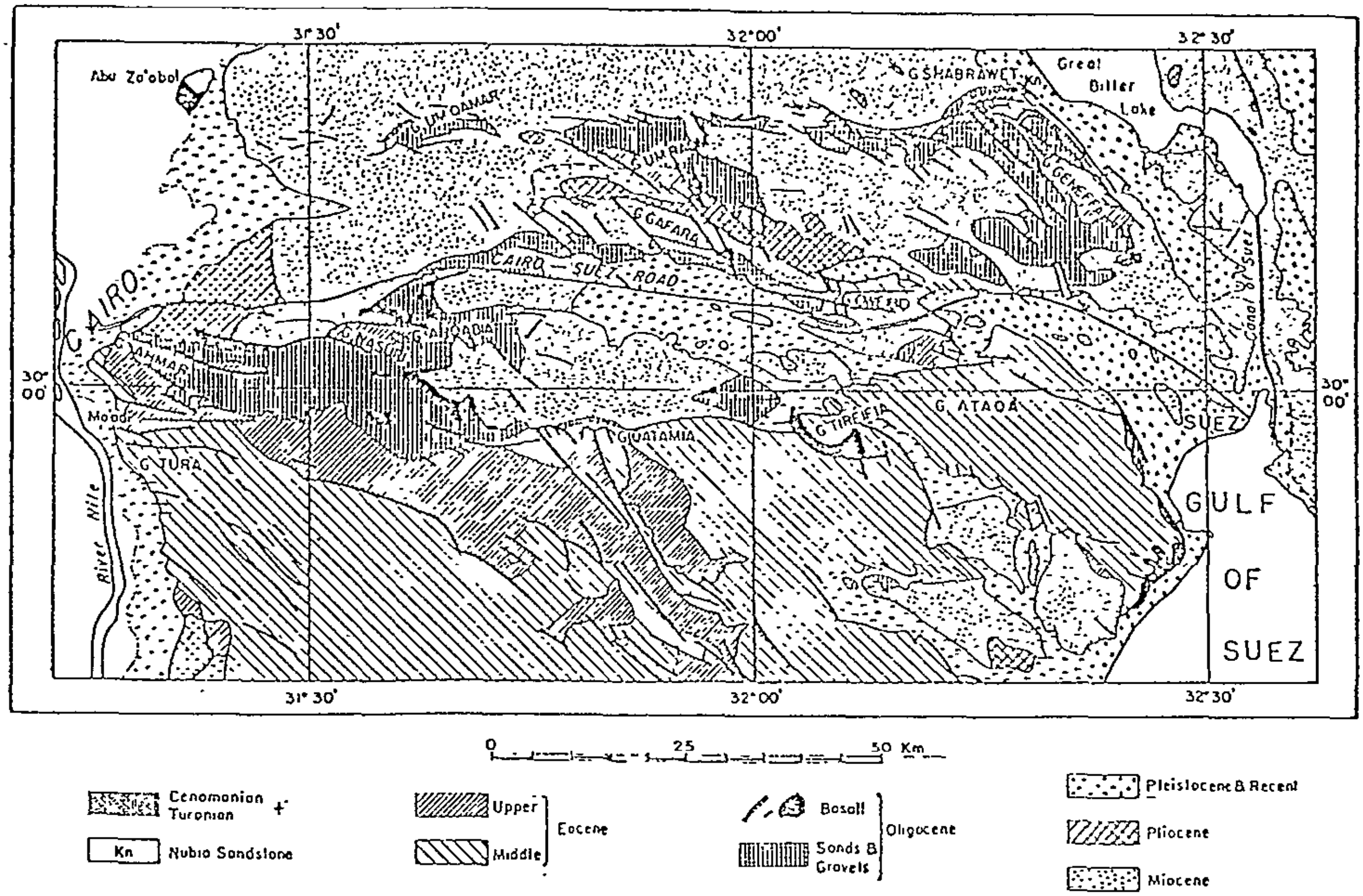


Figure 2. Geology of the Cairo-Suez district (Said, 1962).

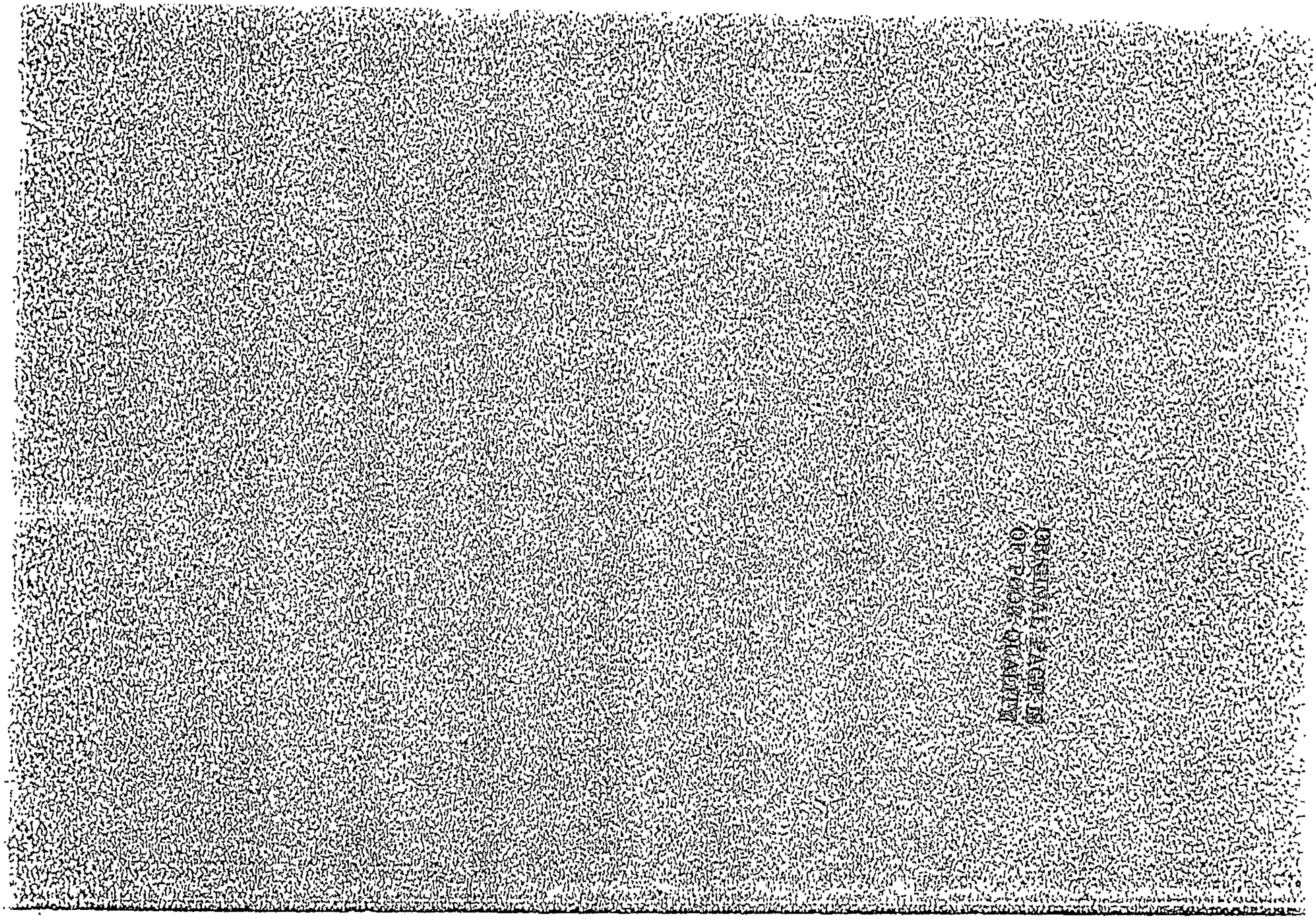
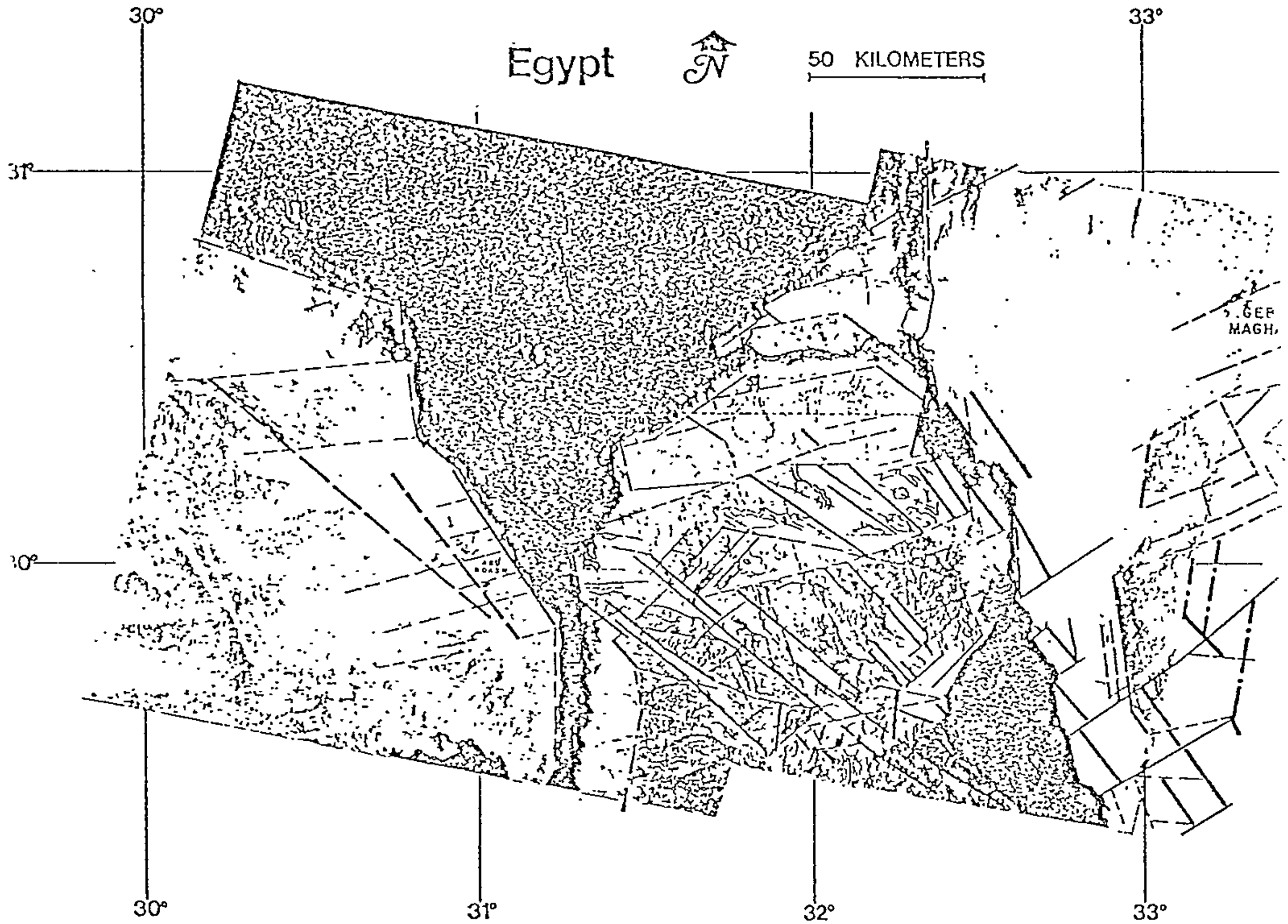


Figure 3. LANDSAT-1 Fals Color Mosaic of Egypt.
Scenes 1236-07552, 16MAR73 and 1165-08002, 04JAN73.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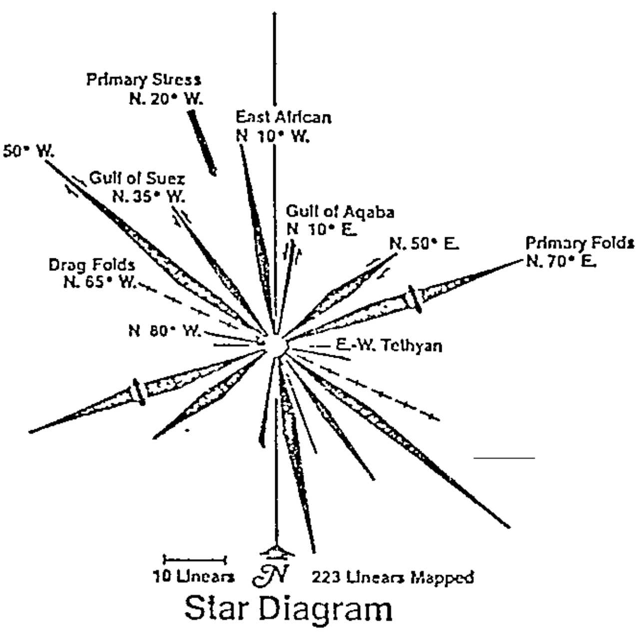

Figure 5. Star diagram illustrating relationships between mapped lineaments.

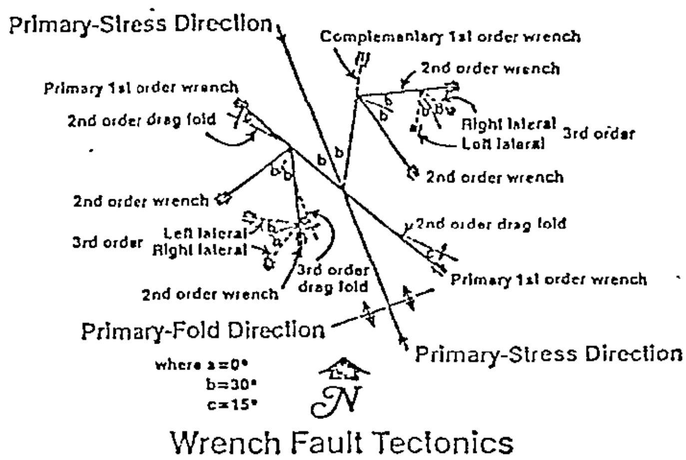

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Figure 6. Wrench fault tectonics as related to lineament interpretation.

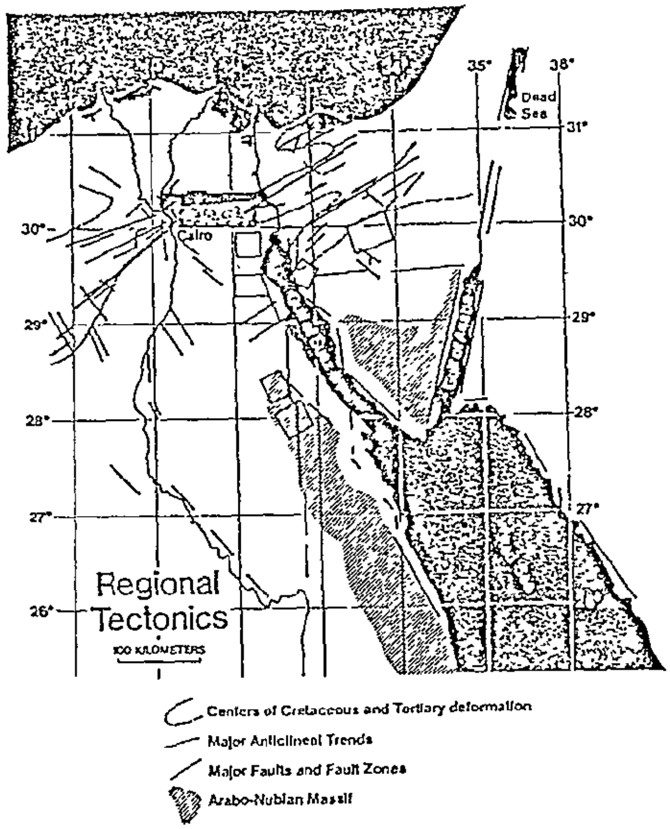

Figure 7 Regional tectonics of North-East Africa (Adapted from

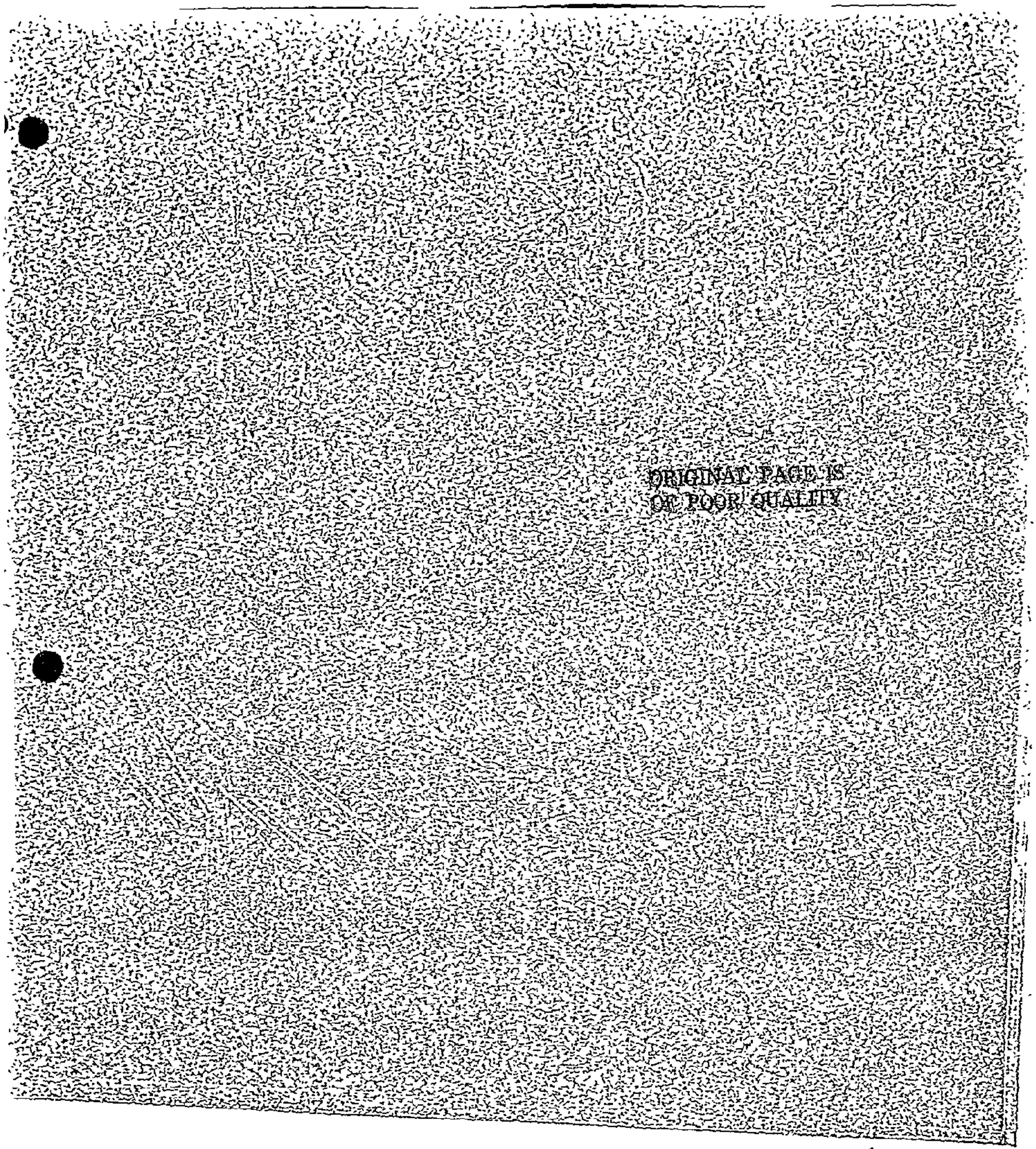

Figure 8. Residual total magnetic intensity map with LANDSAT interpretation superimposed.

Figure 9. Bouguer anomaly map with LANDSAT interpretation superimposed.

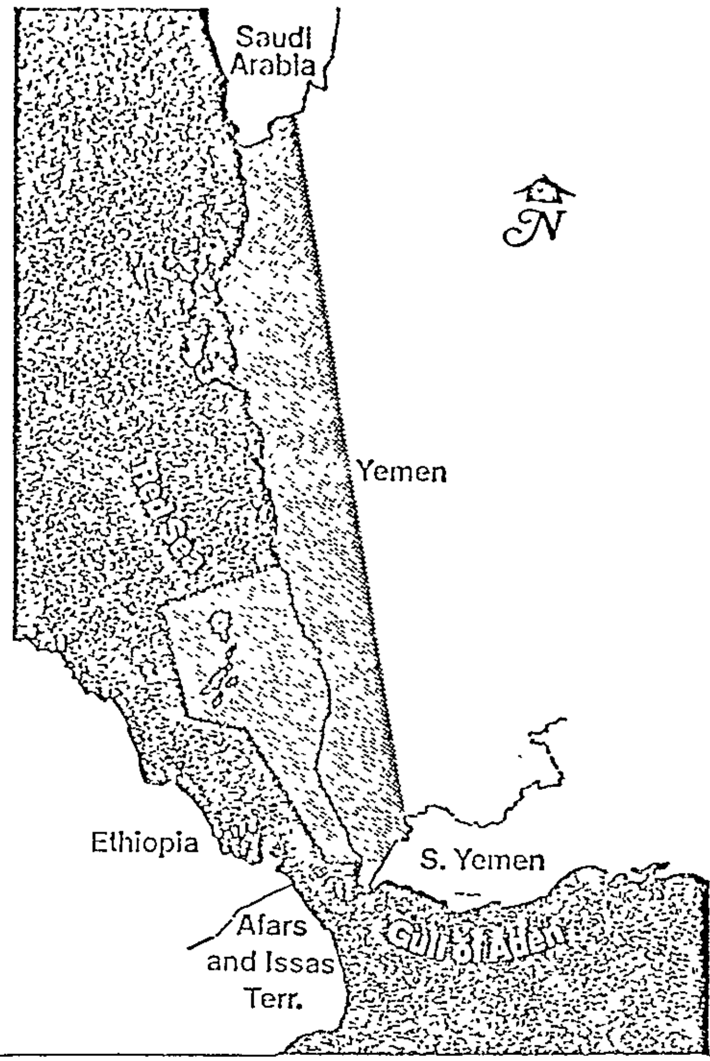

Figure 10. Index map showing Santa Fe Minerals, Inc. exploration area in Yemen.

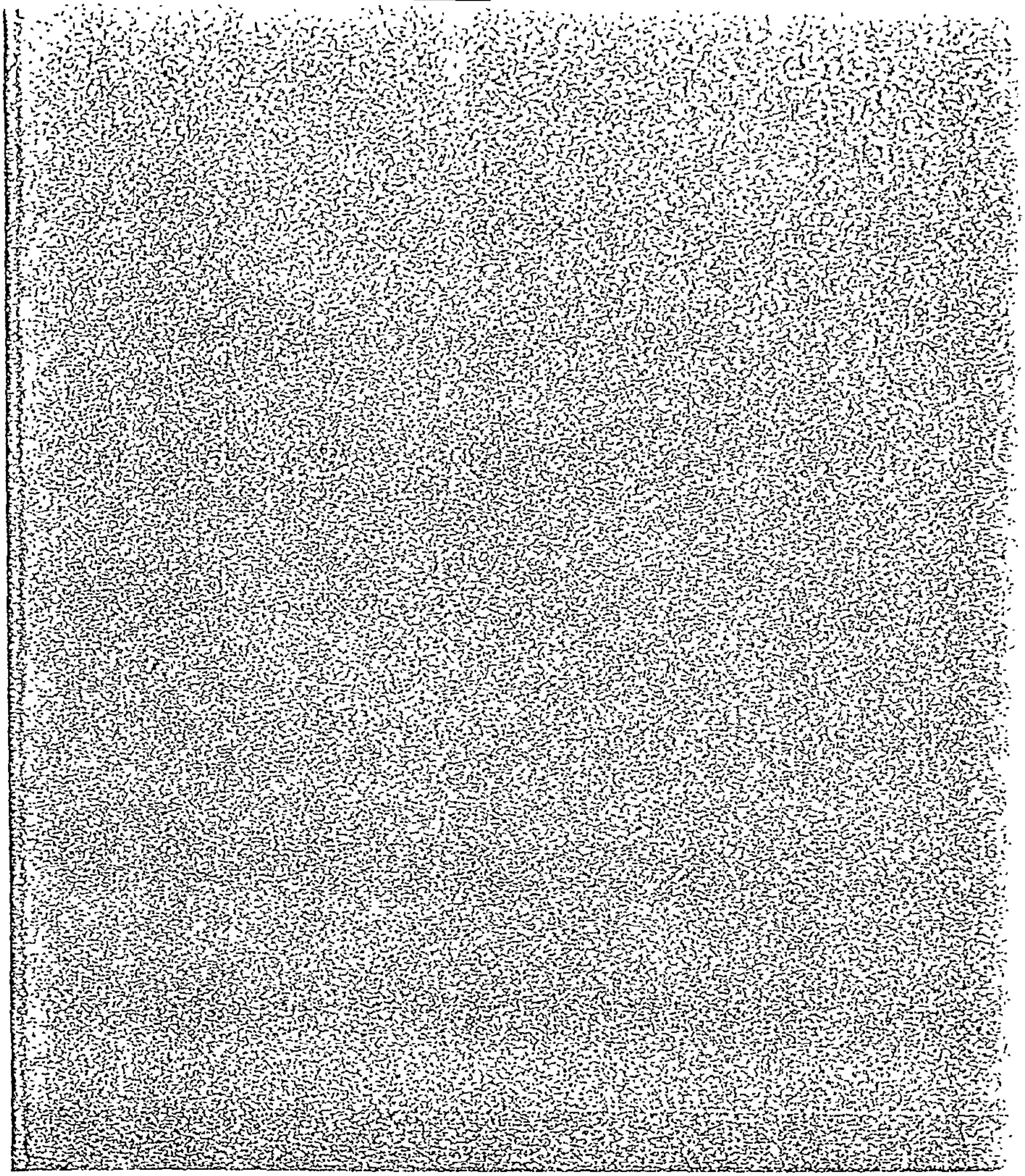

Figure 11. LANDSAT-1 False Color Mosaic of Yemen.
Scenes: 1082-07011, 13OCT72; 1082-07013, 13OCT7
1117-06562, 17NOV72; 1117-06565, 17NOV72.

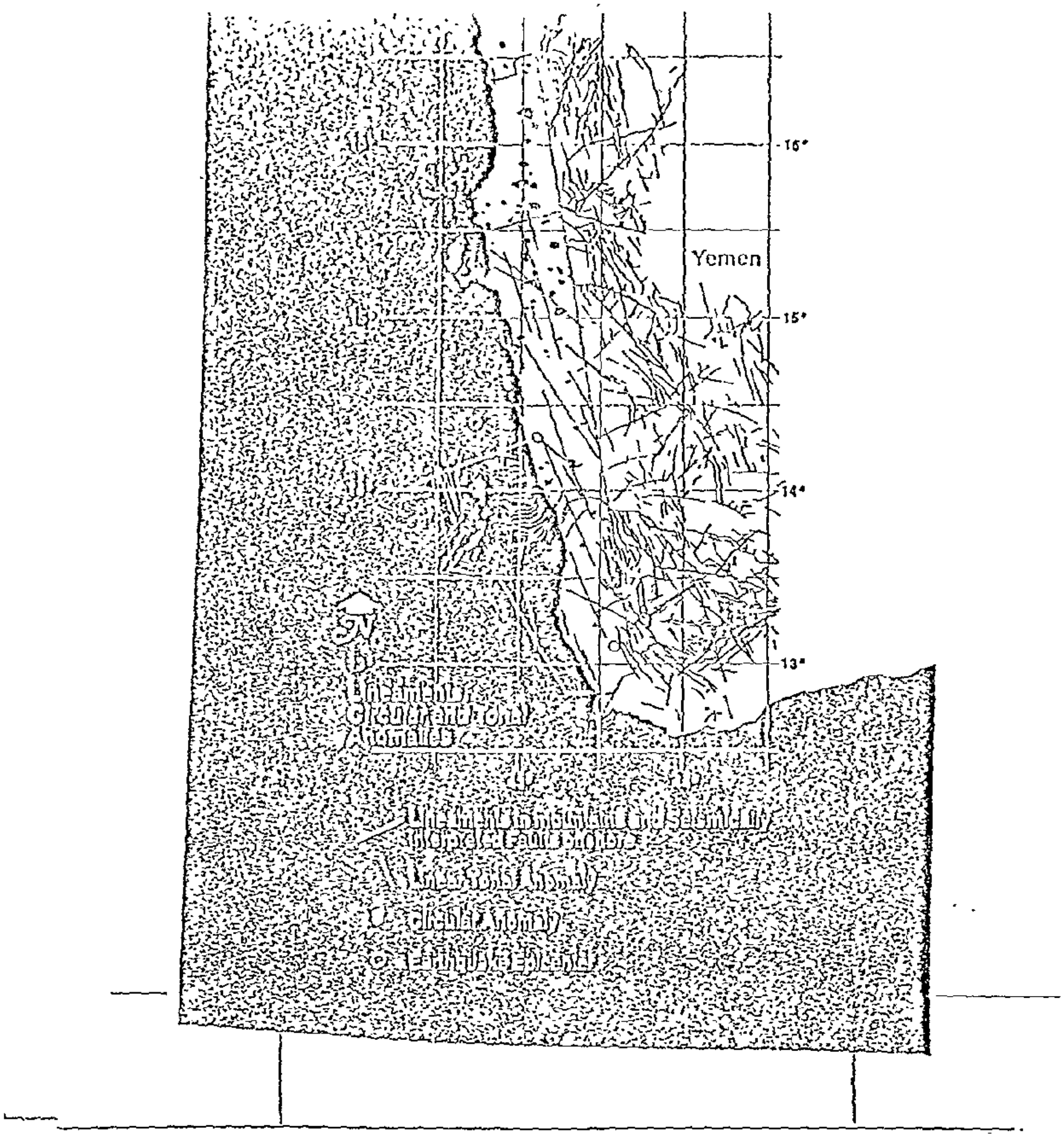

Figure 12. Interpretation of lineaments, circular and tonal anomalies from LANDSAT data.

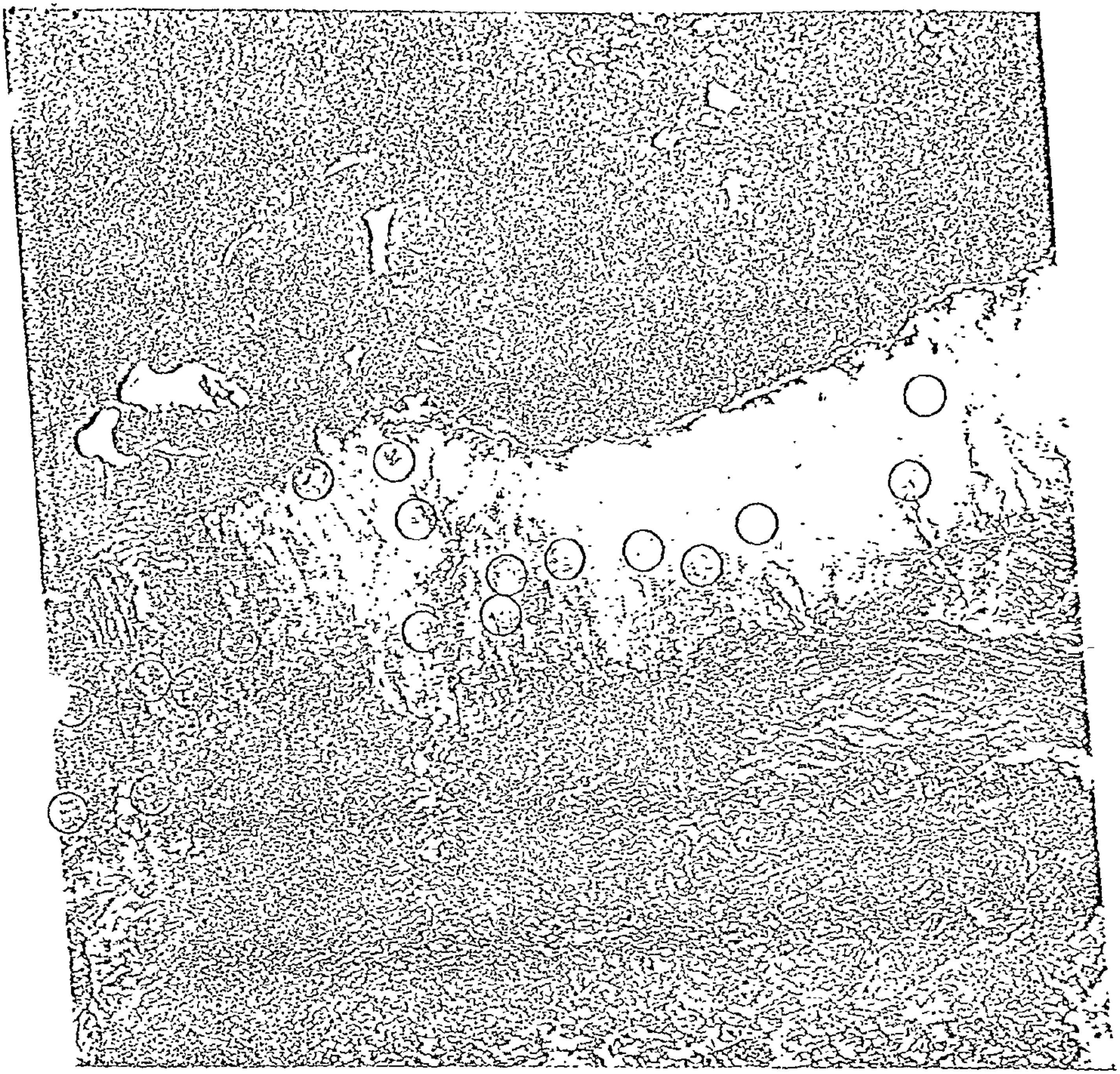

figure 13

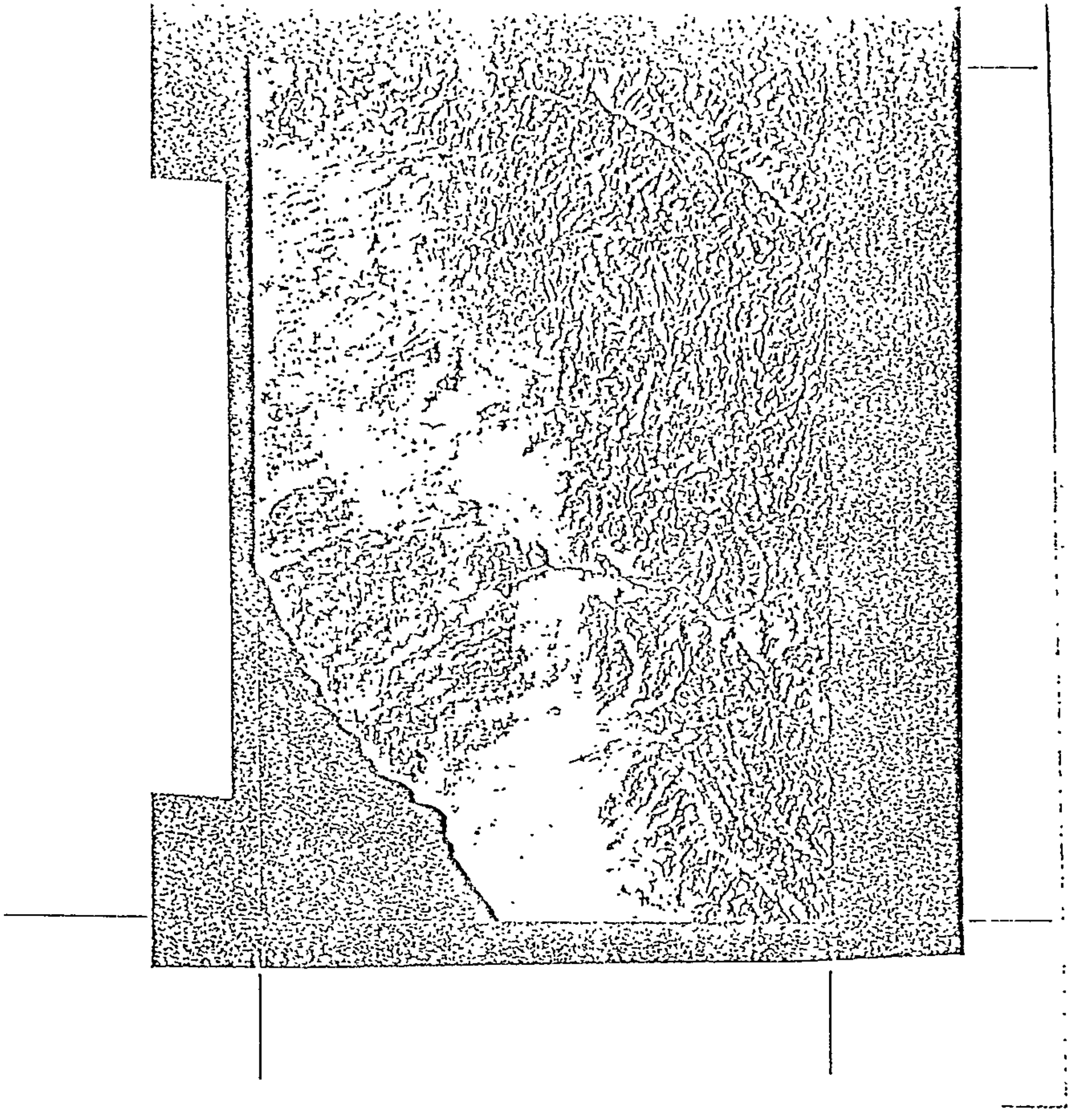

Figure 14. Detail of streaks and tonal anomalies on Yemen coastal plain.

SOUTHERN TIMBERLANDS DIVISION ST REGIS PAPER COMPANY P O. Box 18020, Jacksonville, Fla 32229 (904) 765-3

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July 15, 1976

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Signature of E

Dr. James C. Fletcher
NASA Headquarters
Code A
Washington, D. C. 20546

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Dear Dr. Fletcher:

St. Regis Paper Company is a large diversified timber based company owning or controlling over 5.5 million acres of land in the United States and Canada. In its Southern Timberlands Division, over 1.5 million acres are managed in Florida, Georgia, Alabama and Mississippi. These lands must supply a continuing flow of raw material to three large kraft paper mills and meet the increasing demands of the many alternative uses.

To provide a decision base from which optional management strategies can be selected, operations and executive management depend upon a series of long range planning models. These computer aided models are only so good as the data input to them.

The Southern Timberlands Division is looking toward the LANDSAT satellite system as a significant contributor to an already established forest resource data base. Specifically, we expect this contribution to help broaden the data base, enhance the timeliness of reporting and to establish a more efficient forest data acquisition scheme.

The technical and procedural problems of achieving such a broad based information system may be substantial; however, a greater concern to us is the fact we are dealing with an experimental data acquisition system that has no guarantee of being a continuing source of data.

A non-data continuum is not the only concern. An experimental satellite system such as LANDSAT 1 and 2 may promise no more than a slow, inefficient and awkward data handling system. Such a situation would discourage integrating these data into an operational information system. Although we don't like to think so, it is entirely possible the time and resources committed by St. Regis may be but an academic exercise, with the only marginal consolation being an ability to handle and manipulate multispectral digital data. Such data will surely be of increasing importance in the future. A knowledge of how to analyze these data will be vital, but without LANDSAT and the follow-on program, an important added dimension of information will be lacking. Where, for example, can we have an 8.5 million

acre synoptic view of the earth in one scene? Repeatability of coverage every eighteen days (or 9 days with two satellites) at the same time of day and geographical location, is also a consideration. We know of no alternative platform that could repeat this kind of coverage. We feel, with just LANDSAT 1 and 2, and the state of the art as is, the system warrants operational status. We know that various photographic subsystems will be involved in the whole system. We believe such a multi-staged approach to resource data acquisition is logical, efficient and far superior to what is now in place. We fully expect that LANDSAT C and later LANDSAT D or follow-on will provide data of increased precision and scope such as to improve even further our information base. This is especially true with follow-on and the proposed thematic mapper. I am told there is every reason to expect the increased resolution of 30 meters will allow us to drop at least one level of underflight data. This, along with an increased dynamic range of grey scale to 256 will enhance classification capabilities. Such improvements will have an effect not only on St. Regis total land holdings, but all private and public organizations involved in resource management.

With all this in mind, we strongly urge NASA to vigorously pursue the proposed on-going operational satellite system. We feel such a system is mandatory if proper decisions are to be made as to the management of our natural resources in general, and forest resources in particular.

Sincerely,

Kenneth D. Bailey
Divisional General Manager
Southern Timberlands Division

KDB:jj

cc: Mr. C. M. Turner
Ms. Barbara Williams

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Suspense Date 8-4-76
Prepare Reply for
Signature of E

THE SUPERIOR OIL COMPANY

P O BOX 1521
HOUSTON, TEXAS 77001

July 23, 1976

Dr. James C. Fletcher
Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Dr. Fletcher:

The Superior Oil Company has been utilizing Landsat data in our natural resources exploration program since it was first available to us in late 1972. We have found the data very useful in the early stages of our exploration programs, particularly in areas where we were starting a grass roots exploration effort.

Our effort with Landsat has been two-fold:

1. We supply our exploration people with the best quality data available in their areas of interest and aid them in interpretational techniques developed by our applied Research and Development group.

2. We have a continuing program orientated toward developing better interpretational techniques and specialty products (ratios, special stretches, etc.) which aid in the solution of specific exploration problems.

Our utilization of Landsat data in petroleum exploration has been more limited than in mineral exploration, primarily as a result of our present exploration targets. Our concentration in recent years has been in water covered areas where Landsat has minimal application. However, in areas where our search takes us on shore, Landsat is utilized in our early exploration effort in an attempt to define basin shape and size and determine the presence of surface structure. It is also useful in determining the type of terrain and vegitation which will be encountered in the field, significant problems in many foreign areas.

In my opinion, Landsat type data has it's biggest application in the field of mineral exploration. Landsat type data can save many months to years in the reconnaissance exploration phases of unvegitated areas. We have been successful in a number of areas, both foreign and domestic, utilizing Landsat data to outline specific target areas for ground based exploration.

I have used the term Landsat type data because the present Landsat bands are not optimumly positioned for geologic mapping. In particular, we need bands centered at 1.6 and 2.2 micrometers. The 1.6 micrometer band is proposed for the thematic mapper on Landsat D; however, without the 2.2 micrometer band to utilize in ratioing, its value will be significantly diminished. Our experience indicates that ratioing of two bands in the same portion of the spectrum is much more useful in geologic mapping than single bands.

The increased spatial resolution and dynamic range of Landsat D will certainly be welcomed by the Geologic Community; however, until the bands are placed in an optimum position for geologic mapping, the really large benefits of natural resource exploration from space can not be obtained.

Very truly yours,

THE SUPERIOR OIL COMPANY

Jon W. Davidson

JWD:clh

cc: T. C. Holt - The Superior Oil Co. - Houston
Barbara Williams - N.A.S.A. - Washington, D. C.

TGA

TROLLINGER GEOLOGICAL ASSOCIATES, INC.

W. V. TROLLINGER
President

CONSULTING GEOLOGISTS
TGA Bldg / 2150 S. Bellaire St. / Denver, Colo. 80222 / Phone (303) 757-7141

July 14, 1976

Dr. James C. Fletcher
Administrator
NATIONAL AERONAUTICS AND SPACE
ADMINISTRATION
Washington D. C. 20546

Re: Value of LANDSAT for Petroleum Exploration

Dear Dr. Fletcher:

The purpose of this letter is to bring you up to date on our photogeologic mapping program using LANDSAT in Guatemala and southeastern Mexico. It is with a sense of responsibility that I let you know how useful LANDSAT has been in our oil exploration program there, particularly in light of your help last year in scheduling LANDSAT-2 to acquire coverage in certain cloud-covered areas.

You will remember, I wrote to you on September 4, 1975, and visited your offices in early October and discussed our geologic mapping program in that region. As you know, Trollinger Geological Associates, Inc. (TGA) is a consulting photogeologic mapping company located in Denver, Colorado. For the past fourteen years our company has specialized in photogeologic-geomorphic mapping and advanced remote sensing analysis for petroleum and mineral exploration all over the world. Our staff has an aggregate of over 200 years' experience in mapping more than 2,000,000 square miles of the earth's crust. We have been users of space photography since its inception, and have utilized Gemini, Apollo, ERTS, Skylab and LANDSAT materials in conjunction with conventional and special-purpose aircraft photography and imagery (See enclosed brochure, Exhibit A).

In 1973, TGA completed a detailed photogeologic-geomorphic study (using aircraft photography) of a 1,500 square mile area in Guatemala for our parent company, Shenandoah Oil Corporation (SOC), who held oil exploration rights there.

This was followed up by field work, geophysical surveys and drilling, which resulted in a significant oil discovery by SOC on the Rubelsanto anticlinal structure. Almost simultaneously, a huge oil discovery was made in Mexico, some 220 miles to the northwest on trend with Rubelsanto. This is the giant Reforma Field, estimated now to contain 14-40 billion barrels of oil reserves.

In order to determine the geological relationships between Reforma and Rubelsanto, SOC commissioned TGA to undertake a regional photogeologic mapping project using LANDSAT and SKYLAB imagery in conjunction with all other geologic information available. The preliminary LANDSAT photogeologic study is nearly completed, thanks to you and your staff for obtaining LANDSAT-2 coverage. This in areas of previous cloud cover.

I am sure you appreciate the difficulty exploration companies often have in supplying specific details regarding their early exploration efforts in a given area. Due to the huge expense involved in exploration, much of the information gained must be kept proprietary until development is complete. However, SOC has given TGA permission to provide NASA with reduced copies of our preliminary maps (not for distribution), together with other supplemental information relative to this project. This is done with the hope that it will serve as a demonstration model as to the value of LANDSAT for regional exploration studies for petroleum.

The area studied embraces approximately 380,000 square kilometers including all of Guatemala and Belize, the southeastern end of Mexico and the western parts of Honduras and El Salvador. The space-derived materials utilized included (1) LANDSAT black and white prints (bands 5 & 7) and color composites (bands 4, 5 & 7) at the scale of 1:1,000,000 and (2) SKYLAB color photography (S190B) at the scales of 1:500,000 and 1:1,000,000. Methods of map compilation and geologic interpretations were similar to those of a conventional photogeologic evaluation using aircraft photography, but modified in accordance with the characteristics of the space materials. A black and white mosaic was constructed at the scale of 1:1,000,000 from band 7 images (Plate I-reduced copy). Geologic interpretations were made using the various LANDSAT and SKYLAB images, and annotations were compiled to an overlay to the LANDSAT mosaic. Final maps were prepared from the preliminary base map overlay and prints of these were prepared on linen and hand-colored with lithographic inks.

The interpretation phase involved the utilization of all available published geologic maps and reports to provide background information on the surface stratigraphy, structure and geomorphology. In addition, experience gained by TGA in detailed mapping (using aircraft photography) in the SOC concession area provided invaluable information to add to the data base prior to initiating the interpretation. The detailed analysis of the LANDSAT images was accomplished by

first using the areas of overlap between adjacent orbit tracks. These were studied in stereoscopic perspective, which greatly facilitated discrimination of basic rock units and mapping of structural features. Next, interpretation of the larger parts of each image not overlapped was accomplished using monoscopic methods. A magnifying glass was used to infer and extrapolate the major structural and lithologic data from the sidelap areas and the non-stereo areas.

Plate II is a reduced copy of the preliminary LANDSAT photogeologic map. This work has added immeasurably to our understanding of the geology of the region and promises to be extremely useful as SOC continues exploration and drilling within their exploration block.

Some of the things we have learned are:

(1) Reforma and Rubelsanto lie along the same structural trend, at opposite ends of the Chapayal-Peten Basin, the southern segment of the Gulf Coast Province.

(2) The structural features of the SOC block are similar in character to those of the Reforma and the intervening area of Chiapas, Mexico. The curving pattern of folds and faulted structures give clues to the shape of the basin and patterns of deposition.

(3) The limits and characteristics of the major tectonic features forming the boundaries of the Chapayal-Peten Basin. The left-lateral displacement along the major controlling faults (CCP, Motagua and Jocotan) has produced numerous secondary structures within the basin, many of which probably represent significant hydrocarbon traps.

The total value of LANDSAT to the SOC exploration effort will not be known for years to come. We are presently integrating this regional information into the detailed data derived from wells drilled to date and "on the ground" geophysical surveys. The regional perspective provided by the LANDSAT study has significantly updated our knowledge of the character and chronology of geologic events effecting the region and without it, LANDSAT, this knowledge would have been virtually unobtainable at any price.

It is our intention to soon provide copies of this study to the governments of Guatemala and Mexico. This is being done out of a recognition by SOC that cooperation between Mexico and Guatemala and the exploration companies involved will result in a more rapid development of needed oil resources in this region.

NATIONAL AERONAUTICS AND SPACE
ADMINISTRATION
Dr. James C. Fletcher

I want to again thank NASA and you for your contribution to this project. This is but a single case in point, illustrating the value of LANDSAT for petroleum exploration. I am convinved that natural resources satellites offer the greatest hope for meeting the growing world-wide energy crisis.

In closing, I would like to strongly recommend the continuation of the LANDSAT program as planned, modified in the future to better meet the needs of exploration geologists. I will be happy to provide any additional information you might desire regarding our utilization of LANDSAT in petroleum and mineral exploration.

Very truly yours,

TROLLINGER GEOLOGICAL ASSOCIATES, INC.

William V. Trollinger

William V. Trollinger

WVT:wh
Enclosure

cc: Mrs. Barbara Williams
NATIONAL AERONAUTICS AND SPACE
ADMINISTRATION

TGA

TROLLINGER GEOLOGICAL ASSOCIATES, INC.

W. V. TROLLINGER
President

CONSULTING GEOLOGISTS
TGA Bldg. / 2150 S. Bellaire St. / Denver, Colo. 80222 / Phone (303) 757-7

June 14, 1976

Mrs. Barbara Williams
NATIONAL AERONAUTICS and SPACE ADMINISTRATION
Washington D. C. 20546

Re: Questionnaire on Utilization of Landsat Data in Oil Exploration

Dear Mrs. Williams:

It was a pleasure to meet with you in our offices during your brief visit to Denver last month. The following is in response to your request for information concerning our utilization of Landsat data in the conduct of our geologic mapping programs for petroleum and mineral exploration. As you know, our company specializes in making detailed photogeologic-geomorphic studies for the petroleum and mining industries. In general, we utilize the Landsat data as supplementary imagery to aircraft-derived aerial photography. The following are answers to the questionnaire you gave me, a copy of which is enclosed:

(1) Yes, we have been using Landsat data in regional exploration studies ever since it has been available. Accordingly, we have utilized Gemini, Apollo and Skylab imagery as it has been made available to us. In conjunction with our global exploration efforts, TGA has utilized Landsat data on five continents.

(2) Yes, we utilize Landsat data for regional exploration studies as well as combining it with conventional methods utilizing aircraft aerial photography. Generally speaking, the Landsat imagery provides the overall synoptic view for regional geologic (primarily structural) interpretation which puts the detailed information into its regional context. A particular example of the utility of Landsat data in conjunction with aircraft-derived imagery is that of a recent study our company completed in Southeast Mexico and Guatemala (letter to follow).

(3) It is very difficult to quantify the amount of cost savings effected by utilizing Landsat data over a totally conventional program. This is because the type and quality of information derived is quite different. However, the following information is given for general comparative purposes:

For the Guatemala-Mexico area mentioned above, the cost breakdown roughly is as follows:

a. Detailed study using aircraft photography (approximately) 1500 square miles-\$6.50 per square mile = \$9,750.00

b. Regional study using Landsat (approximately 150,000 square miles-\$.20 per square mile= \$30,000.00

c. \$6.50 per square mile divided by .20 per square mile = 32.5

This means of the unit costs for mapping using conventional photography were 32.5 times more costly than using Landsat. However, the products are totally different in quality and amount of detail and therefore, the cost figures are of limited value. The resultant Landsat photogeologic map was prepared at the scale of 1:1,000,000, whereas the conventional photogeologic map was prepared at the scale of 1:50,000. Thus, the conventional map is more detailed and more comprehensive than the Landsat map - however, the Landsat map provides data that has been heretofore virtually unobtainable at any cost.

Regarding the second question in No. (3), I would suggest that there is no way to make this comparison. Since you are including geophysical costs as well as geologic, the question becomes extremely difficult. The purpose of the Landsat study would be to provide regional information which would give selective guidance to on-the-ground geophysical operations. I would simply say that we have not yet had enough experience with the Landsat data to be able to quantify its value in the conduct of ongoing exploration programs.

(4) Regarding the most beneficial characteristics of Landsat, I would suggest that a. scan large areas (regional synoptic view) and b. discern major structural and lithologic features - would be the most important. If those are the most beneficial, then they should have some impact on cost savings. The amount however is difficult to pin down precisely.

(5) No information.

(6) In regard to different seasonal conditions, our company always uses only one set of conventional aerial photography. This is generally flown to the seasc most appropriate for the type area involved. In regard to this feature of Landsat, this is not at all an important factor in our use. Moreover, I seriously question whether this results in increased accuracy. In regard to a cost savings regarding repetitive coverage during different seasons, this would not result in a cost savings but rather an added expense.

(7) Regarding using Landsat data to select areas for more detailed study, the answer is yes. Again, this is difficult to quantify because it represents the utilization of materials heretofore unavailable. This should be a very significant factor in years ahead, when the imagery is more suited to geologic exploration.

(9) No opinion.

I hope the foregoing information will be of some use to you in the days ahead. I am sending under separate cover a copy of the letter referring to our Guatemala-Mexico study.

Very truly yours,

TROLLINGER GEOLOGICAL ASSOCIATES, INC.

William V. Trollinger

William V. Trollinger

WVT:wh

OIL COMPANIES

1. Have you been using LANDSAT data in regional exploration studies?

2. Do you use only LANDSAT data for regional exploration studies or do you combine it with conventional methods such as aerial photography, reconnaissance surface geology, and seismic surveys?

3. What cost savings in onshore geologic and geophysical (G&G) operations is derived from this use of LANDSAT data over a totally conventional program? Would this represent a 35% savings for your company's onshore G&G operations?

4. Some LANDSAT users have found the following advantages:

   - scan large areas
   - discern major structural and lithologic features
   - see an area many times under different seasonal and atmospheric conditions
   - improve existing interpretations of local areas
   - suppress a large amount of distracting detail permitting subtle large scale differences to be defined
   - see an area in various forms of black and white, multi-color, and multiple bands of infra red.

Which of these features have you or would you find especially beneficial? Which are most related to cost savings? Why?

5. With conventional methods for regional exploration studies did you have to combine local data to get regional information?

   What percent of the G&G expense was associated with this combining?

   Did you find a cost due to the inaccuracy of this method?

6. With conventional methods did you get G&G data on an area under different seasonal conditions? If not, have you found this LANDSAT feature an important factor for increasing accuracy? Could you place a cost savings on this increased accuracy?

7. Have you used LANDSAT data to choose optimal regions for exploration? What percent efficiency have you found? Can you assign a cost savings?

8. Have you found LANDSAT data useful for new seismology techniques namely bright spot analysis?

   If yes can you assign a cost savings to this use of LANDSAT data?

9. If an acceleration in the discovery rate of the existing petroleum stock would occur, do you think it would be beneficial for your company to increase its production rate?

CITIES SERVICE
OIL CO.

CITGO

CITIES SERVICE OIL COMPANY

Exploration & Production Research
Box 50408, Tulsa, Oklahoma 74150
Telephone: 918-586-2211

October 13, 1976

Ms. Barbara E. Williams
Code EK
National Aeronautics and Space Administration
Washington, D.C. 20037

Dear Ms. Williams:

First, I wish to apologize for this delayed response to the questionnaire that you left with us during the brief visit last summer, regarding the utilization experience of Cities Service with Landsat data for onshore geological and geophysical operations. Secondly, it should be understood that the following comments are my specific response to the questions based upon a general knowledge of how the various exploration groups in our worldwide operations view and use the Landsat data and my personal opinion of how the data should be used, now and in the future.

We have used Landsat data, in standard product image format, extensively for regional exploration studies since October, 1972. Whenever possible, it is combined with as much "conventional" data as is available. However, in many of our foreign operations there is usually not a large amount of conventional data already on hand. In those instances of poorly known areas, a Landsat image mosaic is frequently the best approach to quick evaluation of a region, and this type of overview is very valuable both before and after an exploration concession is obtained. Regardless of the relative amount of information on hand, a good image mosaic is an excellent base map for planning of regional data acquisition and subsequent compilation of data to facilitate its integrated interpretation. The resulting regional data base is a necessary step for the definition of prospects that can then be subjected to the very expensive ground geophysical follow-up that must occur to locate drillable targets.

We, like many Landsat users, find that the major advantage of the imagery is the capability that it provides to look at a large area of the earth's surface in such a fashion as to suppress a great amount of distracting detail thereby permitting the detection and mapping of major structural and lithologic features. The information derived from this broad perspective is then combined with conventional types of data, both regional and local in scale, by means of a suitable geological hypothesis to develop new, or

improve existing, interpretations cf more manageable local areas. To get coverage of an equivalent area (13,000 sq. mi.) with standard airphotos would involve a very large number of airphotos (approximately 2,000 photos per Landsat scene), and contracted data acquisition, printing and mosaicking of this size survey would cost on the order of $75,000.00. The required scale reduction to get that amount of photomosaic to a useable size is such that the inherent tonal variation and spatial distortion in the final product renders it relatively unuseable for the sort of study it was intended, i.e., to show large, but subtle, features of geological significance. Also, the time to develop the product to this stage can be inordinately long. The resulting high cost-to-benefit ratio has effectively precluded the general usage of any large area photomosaics.

We know that multi-season coverage may offer more information than a single look by detection of such changes as vegetation cover, soil moisture and sun angle. Many clues of geological significance are transient in nature because of these factors, yet the previously cited costs for an airphoto survey make it unlikely that the clues will be sought after with this tool. Whereas the increased amount of information from multi-season airphoto coverage would probably not be sufficient to warrant the necessary expenditure for it, the fact that repetitive Landsat data is available for such a small price ($12.00 per scene) certainly behooves an explorationist to exploit it for any possible advantage.

The multi-spectral nature of the Landsat data is due similar consideration to that of the multi-seasonal aspects for many of the same reasons. The various views of the same scene that the multi-spectral data provides will often yield considerably more information than any single view which is possible. Of course, the same kind of data can be acquired by a multi-camera airphoto survey, but the previously mentioned factors of cost, mosaicking and scale reduction are seriously compounded by the increased number of photographs that must be considered to do so.

Please note that airphotos and photomosaics have a definite, functional place in most exploration ventures, but they are not well-suited to large region studies which are typically of a "reconnaissance" mode. Conventional photogeologic studies should occur as the second step in the exploration scheme to further reduce the size of areas selected for ground follow-up. I suggest that far too many users of Landsat data are technologically ignorant when they expect to do detailed photogeologic mapping with orbital altitude data. The unquestioned advantage of Landsat type imagery is the synoptic view that it provides by suppressing much of the distracting detail on the earth's surface, yet it is precisely that very same detail which is sought after in photogeologic mapping. The point of this discussion here is that neither satellite nor aircraft data are a replacement for one another, but are indeed supplementary tools to be knowledgeably used for distinctly different (although closely related) phases of exploration.

For these reasons, to attempt a meaningful economic analysis of direct Landsat-related costs and benefits such as this questionnaire is seeking will be very difficult, to say the least, and inevitably misleading in its implications and conclusions. For example, a multi-seasonal (four times per year) regional reconnaissance study of a 13,000 sq. mi. area would cost on the order of $300,000.00 for airphotos and $48.00 for Landsat's multi-spectral images, i.e., an apparently tremendous cost savings just in data acquisition by using Landsat data over a conventional program. But, because of the long lead time, the cost, and the relative effectiveness of the regional scale, the airphoto study would probably not be included as part of a conventional reconnaissance program; therefore, the cost savings are only illusory. Another extreme example would be one relating to foreign operations where airphoto surveys are very costly or impossible to acquire because of political expediency. In such an instance, Landsat data is the only way to get regional reconnaissance structural information, and decisions to bid or not to bid on exploration concessions costing millions of dollars could be influenced by the information provided through a single Landsat image which costs only $3.00.

Landsat data is just another tool, and as such, it may be utilized in various ways and with various effects. In some instances, it can be of singularly beneficial use, e.g., for regional reconnaissance when it provides significant data that is just not available from any other source for a feasible price or in a practical time frame, and in other instances, it is only of supplemental benefit, e.g., when used as a good base map for conventional data compilation.

The EROS concept, and Landsat system(s), is a truly remarkable venture that can only continue to grow and expand in its influence on how we are to handle the challenge of providing the natural resources that are so indispensable to the future. The benefits that have been derived to date are, as I have tried to indicate above, extremely difficult to quantify for precise assessment, but let there be no doubt that the program has made many significant contributions to our efforts already. Cities Service is, as most energy-exploration companies are, a large group of people with diverse technical experiences and information requirements. Therefore, new concepts and tools are all too frequently difficult to introduce and be readily assimilated into the normal scheme of operations. So it has been with the Landsat data, but we now feel that we have crossed the recognition threshold with a large portion of our people. We certainly have done so on a Company philosophy basis as is witnessed by our moral, technical, and financial commitment to the recently conceived Geosat Committee, which is itself perhaps the most conclusive testimony of all in regard to the relevance attached to the EROS program by industry. The information that explorationists have been able to derive from the data content of the Landsat-1 & -2 satellites (which would be more appropriately named "Agrisat" because of their spectral selections) has been very valuable in a dual consideration: first, it has provided a practical method for seeing the regional picture that is so often relevant to our task but was previously unavailable; and secondly, it has served to merely indicate the vast potential that awaits to be tapped through

systematic coverage of the earth's surface by sensor systems that are dedicated to, and spectrally tuned for, geological exploration purposes. It is this latter consideration to which the Geosat program will address itself. Our industry, as a whole, is sufficiently convinced regarding the prospective utility of the EROS concept that we are willing to join together in a loosely-knit, cooperative venture to define, recommend, and support implementation of changes to the system which are deemed to be vitally necessary to fully realize the capabilities which have been envisioned as the direct result of the Landsat program.

Two of these aspects should be briefly commented on here as I believe they are integral to a proper response to the original questionnaire. The batch-processing method whereby the Landsat data is converted to a film product for general public distribution often produces inadequate pictorial rendition which prevents extraction of the full information level of the data content, i.e., some of the images which could have played a measurable role in our exploration activities didn't because the film products obtained from EROS Data Center were severely lacking in tonal contrast which prevented full spectral and spatial resolution fidelity for large geographic areas of interest. Also, the specific spectral windows that have been sampled by the Landsat MSS system, because of their location and broad width, have not permitted realization of the rock-type mapping capability for which we had hoped.

The proposed specifications for the Thematic Mapper to be employed in the Landsat Follow-on program appear to hold great promise towards alleviating many of the problems that we now face. It is our sincere desire that the EROS program remain viable, and hope that it will accommodate the improvements to be recommended by the Geosat Committee whenever possible so that this new tool can be increasingly and constructively used to its fullest extent for geological exploration in the future.

Very truly yours,

Paul G. Harrison

Paul G. Harrison
Senior Research Geophysicist

PGH/msh

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BY WITNESS

III-K

Statement of

Dr. H. LeRoy Scharon
NL Industries, Inc.
Golden, Colorado

before the
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Committee:

It is with a sense of duty and responsibility that I speak on behalf of NASA and its applications program and specifically address my remarks to the value of Landsat to the mineral exploration industry.

When one is constantly reminded of the statistics and statements involving mineral discoveries, such as "today's odds against finding a commercially exploitable metallic orebody as 10,000 to 1," or, "the United States mineral deposits have been exploited to the point of no return," or, "the United States has been a major importer of many raw materials ever since World War II," or "the rate of new discoveries and development of resources is declining for a wide range of minerals," one is tempted to become extremely pessimistic in the expected results of his exploration endeavors. But, as in the past, there is invariably some new technology that always comes to the forefront to change the atmosphere from one of pessimism to one of optimism. I personally, and I am confident that my associates in the task of mineral exploration, look upon that phase of NASA's total program, i.e., the Landsat epoch, as an important new technology that will and is minimizing that pessimism.

NL Industries, although not exclusively a mining company, is a corporation that uses many raw materials in its total business program. As a result, NL does support a mineral exploration group. This unit is dedicated to the discovery of new mineral sources in a minimum of time and at a minimum cost. We, therefore, are constanty monitoring new technology and new geological concepts and employ new technolgy and new geological concepts when we can demonstrate they

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are applicable to our exploration programs. With all modesty, I can assure you that the Landsat program, even in its earlier stages, received not only our attention as to its potential value, but was implemented into our exploration program, where today it is an important and essential element in our total mineral exploration efforts.

While not intending to oversimplify the basic concept of mineral occurrences, it is stated that the chance of finding a new mineral occurrence is based on three simple conditions. First, one must identify a suitable host rock in which minerals of economic quantity may be found. Second, one must locate a favorable geological structure along which and in which mineral sources may travel and be concentrated. And third, one hopes to find actual presence of mineralization. If all three conditions are present then the potential for a major mineral discovery is high. Today, however, in the United States it becomes necessary to carry out mineral exploration in many instances, where none of these criteria are visually evident but of necessity can only be inferred. A large portion of exploration funds, therefore, are expended establishing all of these concepts before a hopefully successful exploration program can be initiated.

The availability of Landsat imagery in its various forms of black and white, multi-color, and multiple bands of infra-red to the mineral exploration industry allows the exploration geologist to scan areas of many thousands of square miles and with his geological knowledge interpret from these individual data and their many combinations, structural features and in some cases actual preparation of rock formations that may serve as host conditions for the concentration of mineral occurrences. With these interpretations at hand, a mineral exploration group has been honed in to specific targets, not only in a diminished time frame but also at the savings of many thousands of dollars, preliminary to establishing a specific exploration program.

One of the important advantages of Landsat imagery is that the exploration geologist has the rate opportunity over a span of time to see the area of interest not once

but many times. Updated imagery reflects changes in atmospheric conditions, diurnal changes, seasonal changes, and in rare cases actual geological processes in action, all of which may be very subtle, yet they enhance the geologist's interpretations, resulting in a more positive commitment as to what he sees. As in all indirect mineral exploration techniques, of which Landsat is an established entity, the success is a direct function of the user's geologiccal knowledge.

Like any new technology, there are always stages of improving or expounding upon the end results. In the case of Landsat, and as a result of the involvement of the geologists' use of same, these enhancements are and will be brought about. For example, Skylab photography enhanced the usage and ultimate interpretation of Landsat imagery where coverage by both was available. The eventual gathering of data through the inclusion of heat capacity sensor mapping and the increase of multispectral scanner technology, will enhance further the geologists' interpretation of the three basic elements that determine the loci of mineral concentrations. I would look for the inclusion of a sensitive magnetometer in conjunction with the Landsat imagery. These potential innovations could assist immeasurably in the reversal of the genral gloom that hangs as a shadow over the mineral discovery problem in the United States.

So far I have been making rather generalized statements as to the value of Landsat imagery to the mineral exploration industry. Just how has NL Industries made use of Landsat data? I shall make an attempt to elucidate, but due to the proprietary nature of our efforts, I cannot be specific. In one instance, by combining Skylab and Landsat imagery over an area of several thousand square miles which has not been mapped geologically we were able to reconstruct a geological structural pattern of faults and infer geological formations. Before sending a geologist into the field, these data were used to identify loci where mineral occurrences, if present, should be concentrated. From a practical point of view, the time element was reduced from a field reconnaissance of two years to several months. This alone represents a saving to NL of several hundreds

of thousands of dollars. If all the mineral exploration units in the United States were to each have a similar experience, which no doubt they have, then the savings in time and money may well be several factors of 10. In another case, which occurred in the United States, observing Landsat imagery over a known mineral district, we observed through the utilization of the infra-red bands, that one could interpret fracture patterns, not evident at the surface, in which ore occurs at 1500-2000 feet below the surface. Applying this technique over another area where a similar host rock at depth is known to exist, similar patterns in the infra-red bands were evident. As a result, over an area extending some 200 miles east-west and 50 miles north-south, specific loci were spotted, an exploration program initiated with a considerable decrease in time and dollars spent, and I might add with an exploration success. These are but two examples. Do we consider our many applications successful? I must answer, in all candor, that the answer is yes.

Occasionally throughout the world-wide mineral exploration industry spanning many hundreds of years, there will come some major breakthrough in technology that enhances the discovery of natural resources. I look upon Landsat as the most important innovation to the mineral exploration industry since the advent of the airborne magnetometer that followed World War II. And just as this phase of remote-sensing developed to its high degree of perfection, I predict that Landsat will experience the same high degree of technology and practical use.

COMMUNICATIONS SATELLITE CORPORATION

[illegible]

Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration
Washington, D. C. 20546

Dear Jim:

We are pleased to respond to your request of April 12, 1976 and the very informative briefing given by Ms. Barbara Williams requesting our assistance in assessing the potential market for the products and services from a prototype operational earth resources system. We believe NASA's efforts in this respect are timely and will help to further the application of this interesting and useful technology.

To date, neither COMSAT nor COMSAT General has been engaged in any business relating to the provision of earth resources data products or information services. However, we have initiated internal studies concerning earth resources systems for the purpose of understanding the technology, its potential applications, and the extent of its current utilization. We also have followed with considerable interest the effort, both domestic and international, devoted to the study of the establishment of an operational earth resources system.

Based on our studies, we believe there is insufficient user demand at this time to justify an undertaking by commercial entities to establish a total earth resources system including the space segment. However, we believe the market for earth resources data products and information services, both within the United States and internationally, has not yet been fully developed. In this context, we believe there are four major factors which would have an impact on the development of the market for earth resources data products and information services. The first factor is whether potential users believe there will be an earth resources satellite system continuously available in the future. A second factor is the extent to which any internationally adopted treaty or statement of principles relating to the acquisition or distribution of earth resources data will restrict the data products and information services which can be provided to potential users. A third factor

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is the extent to which the data products and information services provided to potential users can be expanded and delivered in a more timely fashion. A final factor is the extent to which the marketplace can be stimulated through aggressive marketing techniques and services.

Since it does not appear feasible at this time for private industry to undertake the establishment of an earth resources satellite system, we believe the only alternative for the period through the early 1980's is for the United States Government to establish a prototype operational system. The commitment by the Government to establish such a system is, we believe, an essential first step in stimulating the utilization of earth resources data products and information services. We also believe the Government should take all action necessary to ensure that restrictions on the data products and information services which could be provided commercially from such data sources be kept to a minimum.

While we do not envision involvement of the private sector at this time in the establishment of the space segment of an operational earth resources satellite system, we do believe there may be an appropriate role for a private company in the distribution of data products and services to users, including the U. S. Government, private industry and international entities. Given appropriate business arrangements, the involvement of a private company in such a function could result in the provision of more extensive data products on a timely basis. It also would be likely that such a company would engage in an aggressive campaign to develop the market for earth resources data products. We recommend, therefore, that consideration by NASA of the establishment of a prototype operational system take into account the advantages achievable through involvement of a private company in the distribution of data products to users.

Finally, we wish to note the likelihood that a fully operational earth resources satellite system will involve substantial international participation and cooperation. Given COMSAT's experience and expertise in the definition, establishment, and operation of satellite systems, we believe we could make a substantial contribution to any participation by the United States in an international earth resources satellite system.

We appreciate this opportunity to present to you our views with respect to consideration of the possible establishment of an operational earth resources satellite system.

Sincerely,

Joseph V. Charyk

III-M

AMERICAN SOCIETY OF CIVIL ENGINEERS

TECHNICAL COUNCIL ON AEROSPACE

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Response Date 6/24
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June 7, 1976

Dr. James C. Fletcher, Administrator
National Aeronautics and Space Administration Headquarters
Code A
Washington, D.C. 20546

Dear Dr. Fletcher:

Enclosed please find the results of a survey conducted of 53 committees in the American Society of Civil Engineering (ASCE) to identify potential applications of aerospace technology in civil engineering. This study was completed by the Technical Council on Aerospace (TCAS) last year and indicates that aerospace technology has wide application in the civil engineering profession. Twenty-six of the thirty committees that replied in the survey reflected a strong interest in aerospace related technology primarily remote sensing by listing current and potential applications in their technical areas.

The survey showed that civil engineers are actively involved in many areas in which satellite imagery is being utilized, or has the potential of being utilized, to economically and effectively provide the needs of mankind, including: water resources planning, management and environmental evaluation; ocean and coastal engineering; beach erosion and tidal inlets; longshore sediment transport and currents; river basin planning, navigation and flood control; regulation and stabilization of rivers; urban transportation planning and operations; urban and regional land use planning; extraterrestrial surveying and mapping; oceanographic and hydrographic surveying and charting; hydro power project planning and design; environmental effects of power projects; pipeline planning and location; project planning and formulation for irrigation and drainage systems; surface water supply and hydrology watershed management; weather modification; sedimentation and erosion of rivers, waterways and reservoirs; tidal hydraulics; highway planning and location; engineering geology; soil surveys; rock mechanics; urban runoff; water pollution control planning; environmental quality management; agricultural waste management; non point waste sources; atmospheric pollution; environmental concerns of construction; planning and location of offshore and onshore airports and environmental impact analysis.

Civil engineers are traditionally involved in the planning, design, construction, operation and maintenance of projects that provide a useful service to mankind over an extended period of time. Project concepts are often based on an understanding of natural forces and systems, historic

records of natural events and changes that are occurring on the surface of the earth. Space derived data presents the ability to obtain such information and understanding that could not previously be achieved. Data obtained through the LANDSAT Program demonstrates the capability of advanced types of remote sensing devices to produce not only the comprehensive data base needed for monitoring and management of our resources and environment, but also specialized data needed for solving specific localized problems. In order to estimate future changes or events, many project designs are based upon historic records and the longer the period of continuous LANDSAT imagery available the more valuable these data become.

The civil engineering community is just beginning to realize the full potential of this new technology. Spectral and spacial resolutions have been the major limitations of LANDSAT imagery to civil engineering application; however, the proposed LANDSAT follow-on program with improved sensors should overcome many of these limitations.

The TCAS was formed in 1971 with the following objectives: to stimulate the interest of Civil Engineers employed in aerospace activity in ASCE; to coordinate aerospace related activities of the several divisions and enhance the participation of Civil Engineers in these activities; to coordinate the activities of ASCE with other aerospace-oriented agencies and professional organizations; and to review and respond to proposed aerospace related legislation affecting Civil Engineers. Interest in the Council's activities has increased considerably since it was formed and the Council will become a Division in October, 1976. The Aerospace Division will be one of 17 technical divisions in the 70,840 member ASCE organization.

In consideration of the high potential foreseen for this program, the Technical Council on Aerospace of the American Society of Civil Engineers fully supports the LANDSAT program and recommends that the program be continued.

Respectfully submitted

Earl J Kramer

Earl Kramer, Chairman
Executive Committee

WPJ/ms

copy to: Mr. Russell L. Schweickart
NASA Headquarters
Director of User Affairs
Code EK
Washington D.C. 20546

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AMERICAN SOCIETY OF CIVIL ENGINEERS

TECHNICAL COUNCIL ON AEROSPACE

July 1, 1975

Final Report

on

Contacts with ASCE Committees Concerning
Aerospace Related Applications in Civil Engineering

by

Interdivision and Interdisciplinary Coordination Committee

INTRODUCTION

To obtain information on potential applications of aerospace technology in Civil Engineering, the Interdivision and Interdisciplinary Coordination Committee of the Technical Council on Aerospace wrote letters to 53 ASCE Committees. The contact letter included three questions on aerospace technology applications and are tabulated below:

1. Does your committee think that remote sensing or other aerospace related technology have potential application in your technical area and if so, what applications do you consider the most promising?

2. Do you know of any problems in your professional area currently being solved utilizing aerospace related technology? If so, could you provide the name of an ASCE member that we could contact for additional information?

3. Is your committee planning any technical programs where remote sensing or other aerospace related applications might be included as a part of the program?

RESULTS

About 55 percent of the committees contacted responded to the letter. The results are tabulated in Table 1. Twenty-six out of thirty ASCE committees that replied reflected a strong interest in aerospace related technology by listing potential applications in their technical areas. About half of those responding knew of problems which are currently being solved utilizing aerospace related technology. In reply to question 3, about

Table 1. Summary of Committee Response

RESPONDING COMMITTEE	QUESTIONS[a] Response 1	2	3
1. Envir. Effects of Power Projects	+	+	-
2. Hydro Power Planning and Design	+	0	0
3. Planning and Economics	-	-	-
4. Engineering Geology	+	+	0
5. Envir. Concerns in Geotech. Engr.	+	+	+
6. Extraterrestrial Sur. and Map.	+	+	0
7. Land Use Planning	+	+	-
8. Control of Quality in Const.	+	+	-
9. Exper. Analysis and Instru.	+	-	-
10. Properties of Materials	+	+	+
11. Water Resources Systems	+	0	0
12. Water Resources Program Devel.	+	0	0
13. WW, Harbors, and Coastal	+	+	-
14. Project Formul. Irrig. Drain	+	+	-
15. Ag. Waste Management	+	-	-
16. Weather Modification	+	+	-
17. Water Resources Planning	+	+	-
18. Envir. Aspects of Urban Trans.	+	-	-
19. Water Pollution Control Plan	+	0	-
20. Water Resources Operations	+	0	0
21. Urban Trans. Facilities	+	+	-
22. Embankment Dams and Slopes	+	0	-
23. Pipeline Planning	+	-	-
24. Cartographic Surveying	+	+	0
25. Ocean & Hydro. Survey & Chart.	+	+	-
26. Watershed Management	+	+	+
27. I & D Surface Water	+	+	+
28. Research Council on Performance Struc.	0	0	0
29. Joint Committee on Tall Bldgs.	-	+	-
30. Urban Water Resources Research	0	0	0
TOTALS	2(-) 26(+) 2(0)	5(-) 17(+) 8(0)	17(-) 4(+) 9(0)

[a] Code used: + positive response
- negative response
0 neutral response

10 percent of the committees felt that the topic of aerospace related applications could be included as part of their future technical programs.

A brief summary of the potential application listed in the response to question 1 follows:

A. Surveying and Mapping
   1. New systems for cartographic surveying.
   2. Surveying and mapping applications can be applied in topographic and thematic mapping, resources inventory, geodetic positioning, land use classification and monitoring, satellite geodesy, and mapping of other planets.

B. Geotechnical
   1. Terrain analysis, soils identification and construction materials location.
   2. Identification of geological structural features that will affect the foundations of large structures and groundwater flow.
   3. Soil property data acquisition from air-dropped, remote recording penetrometers or other projectiles.
   4. Detection of geotechnical hazards such as faults and landslides.
   5. Monitor stresses in existing pipelines crossing fault lines to forecast earthquakes.

C. Ocean and Coastal
   1. Satellite positioning at sea.
   2. Delineation of tidal datum boundaries.
   3. Wet lands identification and mapping.
   4. Measuring water currents.
   5. Identification of internal waves in the ocean.
   6. Wave patterns off the coast.
   7. Tracing plumes of eroded material from beaches.

D. Water Resources
   1. Satellite communication links for data transmission.
   2. Data acquisition for modeling and optimization of water resources systems.
   3. Forecast basin water yield and flood flows.
   4. Inventory snow cover and surface water bodies.
   5. Monitor regional and river system floods and inventory flooded areas.
   6. Monitor sediment loads in streams.
   7. Evaluation of weather modification activities by remote sensing.
   8. Inventory of resources.
   9. Environmental data acquisition in project formulation for irrigation and drainage systems.
   10. Monitor water deficiencies in crops.

E. Environmental Quality
   1. Monitor point discharges of contamination and determine optimum discharge points for water pollution management studies. Monitor thermal patterns and conduct thermal pollution studies for power plants.
   2. Monitor feed lot runoff and agricultural non-point sources.
   3. Assessing environmental impact.
   4. Inventorying and monitoring natural and man induced environmental alterations.
   5. Monitor air pollution.

F. Transportation, Power Plants and Pipelines
   1. Pipeline route selection and pipeline leak monitoring.
   2. Transmission line corridor routing and power plant siting studies by providing information on land use, terrain analysis, vegetation, soils and other natural features.
   3. Urban transportation studies including inventory of existing parking facilities, usage studies of parking facilities, inventory of street systems, usage studies of street systems and land use inventory.

In response to question 2, the following list of ASCE members were suggested as follow-up contacts:

	NAME	COMMITTEE MAKING RECOMMENDATION
1.	Roy Hunt, Ward and Assocs.	Environmental Concerns of Geotechnic Engineering
2.	Robert B. McEwen, U.S.G.S.	Extraterrestrial Surveying and Mapping
3.	Charles K. Paul, J.P.L.	Extraterrestrial Surveying and Mapping
4.	W.V. Hull, N.O.S.	Oceanographic and Hydrographic Surveying and Charting
5.	Hellmut H. Schmid, N.O.S.	Extraterrestrial Surveying and Mapping
6.	Merritt J. Bender, N.A.S.A.	Extraterrestrial Surveying and Mapping
7.	Donald Stafford, Clemson U.	Land Use Planning
8.	Mel Martin, Corps of Engineers	Quality Control of Construction
9.	Hsiang Wang, U. of Delaware	Properties of Materials
10.	Thorndike Salville, Jr., Corps	Coastal Engineering
11.	Rudy Savage, Corps of Engineers	Coastal Engineering
12.	George Watts, Corps of Engineers	Coastal Engineering
13.	Perry Davison, Federal Highway	Urban Transportation Facilities
14.	R.O. Hoffman, U. of Neb.	Irrigation and Drainage Surface Wate
15.	D.L. Edwards, U. of Neb.	Irrigation and Drainage Surface Wate
16.	C.C. Euckes, Nat. Resour. of Neb.	Irrigation and Drainage Surface Wate
17.	Frank Haws, Utah State U.	Irrigation and Drainage Surface Wate
18.	Bob Hill, Utah State U.	Irrigation and Drainage Surface Wate
19.	Dick Paulson, U.S.G.S.	Irrigation and Drainage Surface Wate
20.	Bill Burkart, N.C.E.L.	Joint Committee on Tall Buildings

For addresses and phone numbers the reader is referred to the ASCE Directory

DISCUSSION

The Surveying and Mapping profession has been actively involved in aerospace technology ever since the first U.S. satellite was launched. Photogrammetry is the classic and well-developed example of remote sensing. Generally speaking there are the following major areas of application in surveying and mapping: topographic and thematic mapping resources inventory, land use classification, satellite geodesy and mapping of other planets such as the moon, Mars and Venus. Space programs which have acquired data by several sensors has provided information on a research basis to Civil Engineers and others engaged in mapping.

Low level aerial photography has application in the planning and design of transportation and particularly parking facilities in the following areas: (a) inventory of existing parking facilities, (b) usage studies of parking facilities, (c) inventory of street systems, usage studies of the street systems and (d) land use inventory. These techniques appear to have particular application in smaller metropolitan areas which do not have extensive multilevel parking or office buildings.

Several promising applications in geotechnical engineering include terrain analysis for site development, landform analysis, identification and delineation of surficial soil types, and detection of geotechnical hazards such as sinkholes and solution channels, seepage zones, faults, and landslides. Soil property data can be acquired from air-dropped remote-recording, penetrometers or other projectiles.

Remote sensing has the capability of providing aerial coverage of a wide area on a timely basis at a relatively low cost. It offers several applications in electric power transmission line corridor routing, pipeline planning, and power plant siting studies. Color, color infrared, black and white infrared, and black and white photography can be utilized for classification of existing land use, terrain analysis, vegetation inventory, soil surveys and the analysis of other natural features. It was also suggested that ERTS color composites can be used in the initial stages of power plant site selection to provide coverage of a large search area. After the plant is in operation remote sensing can be used to monitor airborne waste discharges from the stacks and thermal discharges into receiving waters such as rivers, lakes and estuaries. The data thus obtained can help improve mathematical modeling resulting in more accurate predictions of future discharges.

Remote sensing and other aerospace related techniques have a great potential and to some extent have been used in the field of water resources planning and management. The Water Resources Systems Committee has identified that data availability may be a limiting factor in the use of water resources systems techniques including modeling and optimization. Remote sensing may be able to provide the additional data

needed for these complex models. Project formulation for irrigation and drainage systems require topographic and soil maps at various scales which have been compiled with the aid of aerial photography. ERTS imagery is currently being utilized to inventory irrigation in Nebraska. Watershed management requires inventory of vegetation, geologic resources, snow cover, flooded areas, and surface water bodies. Along with this is also the monitoring of land use changes which occur in the watershed.

Potential application of reservoir projects include reservoir sediment surveys, determination of groundwater seepage from reservoirs, materials survey for construction materials, studies of wave action to determine the effects of weather conditions and reservoir geometry, monitoring of watersheds for advanced forecasting of river floods and water flows, and identification of slide areas in reservoirs.

It was the feeling of several committees that remote sensing has a tremendous potential in many environmental activities. Aerial photography is a valuable tool in water pollution control activities such as monitoring the ambient environment for unknown accidental spillage or illegal point source discharges. Water pollution control planning activities could benefit greatly in the context of better determination of optimum discharge points, assessing environmental impact from the physical, chemical and biological standpoint and inventorying natural and man induced environmental alterations. In project planning phase planning, remote sensing techniques are used to obtain environmental data for consideration in project development. Data communication links provided by satellites will become important for transmitting large volumes of environmental data.

There are many tried and potential usages of remote sensing in oceanography such as identifying flow patterns, delineation of tidal datum plane boundaries, wetlands identification, internal waves identification by ERTS imagery, satellite positioning and coastal erosion studies. In general a major problem is to extropolate from almost an instant in time to a generalized understanding of the system.

A single ERTS frame has an areal coverage approximately square 100 miles on each side. The spatial resolution is approximately one acre. ERTS imagery has been precision-processed to national map accuracy of 1:250,000 scale maps. One chairman stated that the satellite ERTS is a technology looking for a home and that the major limitation in utilization of ERTS imagery is the resolution. Another chairman reported that the two limiting factors in the utilization of aerospace technology which must be addressed are dollar limitations and the transfer of technology on uses and applications.

CONCLUSIONS

Civil Engineers are strongly interested in aerospace related technology that has potential application in their field. Most Civil Engineers responding to the questionnaire were aware of potential applications of remote sensing to their field but in general were not aware of other aerospace related technology that might have application in their field. It appears that the utilization of aerospace technology in Civil Engineering other than remote sensing is being restricted by poor communication between disciplines.

RECOMMENDATION

In order to advance the transfer of aerospace technology to Civil Engineering, it is recommended IICC develop service reports to other ASCE divisions on selected areas of aerospace technology which appears to have potential application such as:

1. Application of program management as developed by aerospace industry to Civil Engineering construction. Coordinate this activity with the Construction Division.
2. Application of stress analysis computer programs developed for aerospace industry to structural analysis for Civil Engineers. Coordinate this activity with the Technical Council on Computer Practices and Structural Division.
3. Application of data collection, transmission and processing technology to Water Resources and Environmental Engineering. Coordinate this activity with Water Resources Council and Environmental Engineering Division.

Respectfully Submitted,

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Miguel Diaz-Gonzalez, Chairman

W. David Carrier, III, Member

E.G. Anderson, Member

Allen F. Flanders, Member

Wesley P. James, Contact Member

N. BP ALASKA
EXPLORATION INC

BP ALASKA EXPLORATION INC.

100 Pine Street, San Francisco, California 94111. Telephone (415) 445-9400

EXP-NS-761/11

November 10, 1976

Dr. Martin Swetnick
Headquarters, Code ERR
National Aeronautics and
Space Administration
Washington, D. C. 20546

Dear Dr. Swetnick:

As you are aware, BP Alaska Exploration Inc. (BPAE) is an original participant in the recently completed Alaska Oil and Gas Association (AOGA) Arctic Research Subcommittee project #26, "Sea ice conditions in the Beaufort Sea derived from four years of Landsat satellite data." This study was carried out by Environmental Research and Technology, Inc. (ERT) from their Concord, Massachusetts, office. Jim Barnes of ERT has already written to you (28 September 1976) oultining the scope of the study. I understand that more specific information on how industry uses sea-ice satellite data would be helpful to your office for planning on-going and future satellite programmes. Some present and possible future BPAE uses for such data are outlined below.

My own responsibility within BPAE is to define methods for, and estimate the cost of, oil and gas exploration and production operations in prospective U.S. offshore areas. In the Arctic and Bering Sea, this effort also requires original engineering research and a detailed understanding of the operating environment. Satellite imagery is particularly useful in this respect, notwithstanding known limitations of the present systems with regard to continuity of coverage, lack of visibility at night and through fog and cloud, and degree of definition.

Even a brief reference to the Proceedings of the Arctic Institute of North America Symposium on Beaufort Sea Coast and Shelf Research (1974) establishes how fundamental satellite imagery has been in determining present engineering understanding of the Arctic offshore environment. Some particularly relevant papers presented at this symposium include:

"Morphology of the Beaufort Sea Shorefast ice" by W. J. Stringer, Geophysical Institute, University of Alaska.

"Ice forecasting in the Beaufort Sea" by William S. Dehn, Sea Ice Corporation, Md.

"Potential use of satellite infrared data for ice thickness mapping" by Leonard A. LeSchack, Development and Resources Transportation Company, Md.

"Analysis of shear zone ice deformation in the Beaufort Sea using satellite imagery" by W. D. Hibler et al. of CRREL.

"Sea ice as a geologic agent on the Beaufort Sea Shelf of Alaska" by Erk Reimnitz and Peter Barnes, USGS, Menlo Park, Ca.

Perhaps because Menlo Park is so close to BPAE's own San Francisco office, I have had several discussions with Reimnitz and Barnes on their Beaufort Sea work. Their ongoing use of satellite imagery is a typical example of the direct benefit to industry of the Landsat and other programmes.

AOGA project #26 was initiated to codify available satellite sea-ice data into the most suitable form for industry to use during pre-lease sale evaluation and preliminary planning of offshore operations in the area of the upcoming State/Federal lease sale between the Colville and Canning Rivers. The report is well done. As a result, BPAE and some other companies have discussed with ERT preliminary specifications for a similar effort in the Bering Sea. The urgency with which industry continues to treat this area will depend upon the revised OCS lease sale schedules which should be published shortly. However, consideration of some preliminary requirements for this study will show typical uses of satellite sea ice data to best advantage. My own comments to Jim Barnes on requirements for a Bering Sea study of sea-ice conditions based upon satellite data include the following points:

1. Present published data have concentrated on mapping sea-ice conditions in the Bering/Chukchi seas from the requirements of marine navigation.

2. The Arctec study, "Feasibility study of Bering/Chukchi Seas production and marine transportation system" (AOGA project #25 for which ERT analyzed the satellite imagery) improves upon published data with regard to extent of ice coverage, but concentrates upon the operation of crude oil tankers on a year-round basis and optimum siting of possible terminal locations.

3. There are no adequate data available on ice conditions, ice features, and general ice movement over the whole area which can be used for preliminary evaluation of the type of development facilities which will be required offshore, and for outline design and costing of fixed production platforms, etc. This is the specific data gap the (proposed) study should fill.

4. The study should cover all prospective OCS sale areas in the Bering/Chukchi Sea. The St. Georges Basin should be included despite Marathon's proposal for a satellite interpretation programme aimed specifically at this location. The ERT study should be comprehensive and definitive for the whole Bering Sea.

5. Specific questions to which answers should be obtained include:

   a. In which areas is the ice comparatively stationary, and in which areas is significant motion observed from time to time?

   b. In which areas is the ice sheet comparatively undeformed; where do significant ice features occur, what are these, how do they move?

   c. Specific imagery and consideration of the edge (10 to 20-mile band) of the ice sheet as it advances and retreats seasonally. This is required, as a basis for further study to determine the possible effects of ice floes impacting under storm conditions with fixed platform structures, and to evolve most suitable fixed platform designs and protective measures. In the end, the data on average and extreme edges of the ice sheet will be related to expected wave height occurrences on a month-by-month basis from October through May, although this is well beyond the scope of the present study. It may prove necessary to adjust the distance from the ice edge considered, as this will be a function of the different wave height dampening effects of different degrees of ice coverage. In view of the low degree of definition available from satellite imagery (based upon AOGA project #26, 500 m seems to represent the lower limit of positively identifiable floes considering the resolution capabilities of the Landsat MSS sensor), a follow on project using U2 (if available) or other photographic data may also be required.

d. Inasfar as it is essential to an understanding of the whole seasonal process, and compliments such work as the proposed University of Alaska radar ice movement station in the Bering Straight, how does the ice move and deform in the immediate Bering Straight area?

e. One important consideration might be to consider changes in ice conditions, ice movement, etc., in each prospective area on a seasonal basis.

f. Any easy observations which can be made relating ice movements, ice coverage, etc., to currents, winds, and sea conditions occurring at the times of observation; also to the predominant wind/current conditions and significant deviations from the same.

Summarizing the general pre-lease sale requirement, as industry considers each new Arctic area, analysis of sea ice conditions using satellite imagery will be required. More detailed photographic studies (such as the U2 flights over Prudhoe Bay) will follow, as these give better definition of small ice floes and features. Low altitude photographic and on ice surveys are needed for final local control. With ongoing development of the U.S. oil industry's Arctic offshore engineering capability over the next few years, satellite imagery with only limited local control will more and more become sufficient for pre-lease evaluation of Arctic offshore areas.

In this respect, you will already be aware that the University of Alaska and BLM/NOAA Alaska Outer Continental Shelf Environmental Assessment Program (OCSEAP) both have ongoing and proposed studies which use sea-ice data obtained from satellite imagery. These include:

"Study of climatic effects on fast ice extent and its seasonal decay along the Beaufort Sea coast," Roger G. Barry, University of Colorado. OCSEAP research unit #244.

"Morphology of Bering near shore ice conditions by means of satellite and aerial remote sensing," W. J. Stringer, University of Alaska. OCSEAP resarch unit #257.

"Operation of an Alaskan facility for application of remote-sensing data to OCS studies," Albert E. Belon, University of Alaska. OCSEAP research unit #267.

In addition, William Stringer has carried out useful work on synoptic morphology and dynamics of shorefast ice in the Beaufort Sea; and Gerd Wendler, also of the University of Alaska, has investigated causes of unusual sea-ice conditions in the Beaufort Sea during summer 1975. This is particularly interesting as Wendler relates synoptic meteorological data to sea-ice conditions off the North Slope. If Wendler develops his work further, to forecast movement of the edge of the pack ice during the summer open water season several days in advance, such a combined use of meteorological and satellite data will be extremely useful to industry when offshore exploration and construction operations start in the Alaskan Beaufort Sea. The development and optimum use of such a forecasting model will require the ability to read future Landsat imagery in near real time. Additional uses of satellite observations during Arctic offshore operations, for instance for optimum routing of barge convoys, or when operating dredges or other floating equipment beyond the barrier islands during the summer open water season, are likely to remain limited until more continuous satellite coverage is available on a real time basis. The cost-effectiveness of providing such service, compared with the present system of observations from spotter aircraft, will require careful evaluation.

The two principal limitations of present satellite data for my own requirements are lack of resolution and lack of winter observations. It appears difficult to determine size and distribution of floes smaller than 500 m across. More detail may not be required in the Alaskan Beaufort Sea where movement and deformations of solid sheet ice, pressure ridges, etc., present the worst offshore design conditions. For the Bering Sea a distribution analysis of the sizes down to 10 m will finally be needed to establish limiting operating conditions at the edge of the pack for floating exploration rigs, and to determine fixed offshore platform design criteria in areas of open pack ice. It is also difficult to build up a complete picture of sea-ice conditions with the present gap in Landsat imagery from early October through early April due to darkness. Particularly in nearshore Arctic areas, ice movement could be at a maximum during this winter period. Lack of winter observations may also limit the overall usefulness of satellite imagery in some Bering Sea areas.

I hope the above explanations are helpful and explain in greater detail some present industry uses of sea-ice data obtained from satellite imagery. Such uses, both in the pre-lease

sale phase and when projected into possible future operational requirements, are perhaps most analogous to the established engineering and meteorological need for synoptic weather charts. Both give general situations over large areas; both are necessary for a proper understanding and interpretation of local conditions; both are obtained directly from broadly based environmental data gathering programmes funded by the Federal Government.

My direct telephone line in San Francisco is (415) 445-9524. I shall be happy to answer any further questions you may have or discuss items of particular interest in greater detail.

Yours sincerely,

Cyril E Arney

Cyril E. Arney

CEA/ep

cc: J. Barnes ERT
AOGA project #26 participants

APPENDIX IV

FOREIGN USERS

TABLE OF CONTENTS

A DISCOVERY OF
LITHIUM IN BOLIVIA

Paul IV-A

AUG 27 1976

ERR/CKP

MEMORANDUM

TO: ED/Deputy Associate Administrator for Applications
THRU: ERE/Deputy Director, Earth Observations Programs

FROM: ERR/Dr. Charles K. Paul

SUBJECT: Lithium and the Significance of the Landsat-Contributed Discovery at Salar De Uyuni, Bolivia

REF: (1) Lithium Resources and Requirements by the Year 2000, conference sponsored by the US Geological Survey Lithium Exploration Group, January 22-24, 1976, Green Center Auditorium, Colorado School of Mines, Golden, Corlorado
(2) Carter, W. D., Kowalik, W. S., and Brockmann, C., "Mapping Andean Salar Deposits by Landsat Radiance Values," paper presented at the XIX Plenary Meeting of COSPAR, Philadelphia, PA, June 8-19, 1976
(3) Telephone conversations with Doug Carter of USGS

ENCL: (1) Colored Processed Landsat Product
(2) Color Table for Landsat Product
(3) Reflectance Curves of Salar Classes
(4) Lithium - Nature's Lightest Metal, US Department of the Interior Geological Survey INF-75-27

Significance of Prospective Andean Salar Lithium Finds

The most important present sources of lithium are the Tin-Spodumene Belt, North Carolina; Clayton Valley, Nevada; Bikita Tinfields, Rhodesia; Preissac-Lacorne District, Quebec; Bernic Lake District, Manitoba; Great Salt Lake, Utah; Salar De Atacama, Chile; and, Manono-Kitotolo District, Zaire. James Vine of the USGS, Denver, claims that in the future, the best chance of finding new deposits of lithium is in

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association with non-marine salt bodies. Areas with borates and nitrates (like Salar De Atacama, presently being worked by the multi-national Foote Co.) in non-marine basins of Tertiary Age contain lithium in clastic rocks, volcanic ashes, clays, and magnesium-rich carbonate rocks. Once dissolved in these materials, lithium tends to remain in solution in residual brines, even after evaporative concentration and precipitation of the salts of sodium, potassium, and magnesium. Brines associated with these evaporative minerals may contain as much as 1,000 times more lithium than sea water.

Hence, the present interest in the Central Andean Salars as possible new sources of lithium. George Ericksen of the USGS has begun to concentrate his lithium exploration efforts in the salars and nitrate deposits of northern Chile, western Bolivia, and northwest Argentina. To provide you a perspective of lithium concentrations which are economical to mine, most nitrate ores generally contain 20-50 mg/liter of lithium, most Chile Andean salars contain 200 mg/l lithium, and the famous Salar De Atacama contains brine having up to 1,000 mg/l of lithium. Thus, for several years, geologists have been eyeing the brines of the Salar De Uyuni in Bolivia. This Salar is big, vehicle access is difficult, and the nationalized mining interests in Bolivia have all discouraged adequate exploration of Uyuni. The only active mining presently in the area is hand shoveling for salt near Colchani. In the past, silver ores have been processed at Uyuni. The samples taken from Uyuni as a result of the Landsat analysis are startlingly revealing lithium concentrations ranging from 600 to 2,300 mg/l.

The Landsat Contribution

In recent years, Bruce Smith and Don Mabey of the USGS in Denver have been exploiting gravity and electrical surveys and geophysical, seismic, and remote sensing techniques for the exploration of lithium. Doug Carter made the major breakthrough in directing ground surveys for lithium in Uyuni after Image 100 analysis of Landsat CCT's of the white salt structures which generally saturate the Landsat images. The results of the analysis is the Landsat processed scene (Enclosure 1) and its color code table (Enclosure 2). A supervised cluster analysis of Landsat CCT's based on the reflectance classes (Enclosure 3) provided the reflectance classes shown in Enclosure 1. These classes, by the way,

have been shown to correspond with previously mapped surface units from aerial photography and correlative field data from Uyuni. Landsat analysis was generally significant in breaking out, for a large area, the water, salt brine, and dry salt themes for Salar De Uyuni. Doug feels that some of the more subtle color differences (not classified in Enclosure 1, but existing in the Landsat digital data) may be due to surface roughness characteristics caused by dry, salt beds and their associated uniform linear fracture patterns with inlaid salt ridges. The regional checkerboard fractures and ridges vary sufficiently to have been felt by Doug as his ground vehicle went from one fracture pattern to another.

Doug and his crew visited Salar De Uyuni in late April 1976. Twenty-two samples were taken at 10 km intervals along a 138 km line westward from the town of Colchani across the Salar. The upper 10 cm of salt surface were collected at each site and two surface water samples were taken where available. Chemical analyses of these samples show very high concentrations of both lithium and potassium, as mentioned above for the lithium concentrations. As a result, the Bolivian government announced the finding of lithium in Salar De Uyuni on July 10, 1976. Doug is returning to Uyuni with two of his geologists this September to locate more brine deposits for ground sampling. He plans this year to coutinue analyzing Landsat scenes at various seasons to identify salar brines in depressions where the water cover varies from 0 to 70% (depending on the season). He hopes to find correlations between very subtle contrast differences on the Landsat scenes and lithium concentrations in the brines.

<u>Lithium as a Resource</u>

The United States exports 24% of its total lithium production. We are the largest producer of lithium in the world, and we exceeded Russia in total production of this resource for the last three years. Only three US companies produce primary lithium products. The total US annual production capacity is 5,000 tons of contained lithium, over 70% of the world total of 6,900 tons.

Although global consumption is not expected to catch up with production of lithium for twenty years, there are two future technologies which consume lithium at rates which concern geologists and which will begin to seriously deplete global lithium resources by the turn of the century. These technologies are the lithium-aluminum/iron sulfide battery and the fusion power reactor.

Lithium batteries are presently under development at the Argonne National Laboratory. Their application for the electric utility industry is off peak-load electrical storage, and for the private consumer the electric vehicle. The battery is expected to come into commercial use around 1985. By the year 2,000, 30% of US electric consumption is expected to be supplied by off peak energy storage batteries. Eighteen million electric vehicles are projected so that by the year 2,000, the lithium demand will catch up to the present estimate of reserves.

The fusion reactor employs a reaction between deuterium and tritium. Deuterium is obtained in large quantities from water; tritium, however, is not an abundant isotope of hydrogen. Thus, tritium is produced by fusion neutrons bombarding lithium. The first demonstration of the fusion reactor is planned for 1997-1998, commercial production is planned for 2007-2008.

If these two technologies develop as planned, the importance of discovering new lithium sources cannot be overstated and the capability of Landsat to locate brines in salt flats indicative of high concentrations of lithium has been demonstrated in the Salar De Ayuni. If the USGS can quantitatively make positive correlations between Landsat spectral differences and lithium concentrations in brines, they will have made a fundamental contribution to new future energy source identification and a significant verification of satellite remote sensing capability to locate these sources.

ORIGINAL SIGNED BY

Charles K. Paul

4 Enclosures

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cc: (w/o Enclosure 4)
ER/Stoney
ERE/Thome
ERR/Morrison, Rogers
EK/Telsher
I/Zimmerman

bcc:
ER/Chron
ERR/Official

ERR/CKPaul:tg:58628:8/26/76

B DISCOVERY OF
MINERALS IN EGYPT

ERR - Office 254

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Satellites Discover Minerals for Egypt

CAIRO (AP) — Plumbing the desert sands from outer space, American satellites have revealed the existence of water, oil, uranium and other minerals in the Egyptian Sahara and the Sinai Peninsula, an Egyptian scientist says.

Ahmed Abdel Hady said photographs taken by the ERTS-1 and Landsat satellites are still being analyzed but preliminary indications show enough water in the Sinai Desert "to turn most of it green." Most of the Sinai is still occupied by the Israelis who seized it in 1967.

Abdel Hady heads an Egyptian-American scientific team in charge of the Remote Sensing Project which has been receiving data from satellites and other space devices since 1972.

In addition to the desert potential, Abdel Hady said in an interview, previously unnoticed fertile areas near the Nile Valley could provide food for thousands of Egyptians.

Oklahoma State University and the University of Michigan, in cooperation with the Egyptian government, have a budget of $1.2 million annually for study of the untapped resources, Abdel Hady added.

"Six images from ERTS-1 last year showed that the Sinai Peninsula has huge water, oil and mineral resources," Abdel Hady said.

"We photographed some 3,500 square miles in Sinai extending from the north to the south."

Shots showed three different areas rich with petroleum and natural gas, he added.

The first is the Gulf of Suez which already has proven oil reserves. The second is the Mediterranean offshore area in northern Sinai which has not yet been explored, and the third is a large area in southern Sinai marked by sedimentary rocks carrying natural gas, Abdel Hady said.

The highlands in northern Sinai and the coastal strip of Wadi el Arish, totaling more than 2,000 square miles, conceal huge water potential, "enough to turn most of Sinai Desert green," Abdel Hady said.

He declined to go into details, saying, "I don't want to make it difficult for Egypt when it negotiates the next Israeli pullout."

Uranium also was detected in northwest and southern Sinai, said Abdel Hady.

West central Sinai, at Wadi el Korbra, contains huge quantities of silica that could lead to a glass industry, he said.

Satellite images also showed significant food-growing potential in a 2,500-square-mile area adjacent to the Nile basin.

Satellite images also were used to study a huge hydroelectric project proposed in the Quattara Depression in the desert west of the Nile Valley.

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TRANSLATION

Al Ahram DAILY DATED. [illegible] November, 1975

THE SATELLITE DRAWS THE FUTURE OF THREE EGYPTIAN GOVERNORATES: FAYOUM BENY SWEIF AND MENYA

According to a scientific agreement for cooperation between the Egyptian Academy of Scientific Research and Technology and the U.S. National Science Foundation and National Aeronautics and Space Administration (NASA), the satellite images from NASA LANDSAT were used to make it possible for Egypt to discover new areas of iron-ore deposits at the Western Desert along the Nile Valley. The areas discovered are in the provinces of Fayoum, Beny Sweif and Menya, at a distance of about 100 km from the Nile Valley.

These deposits will assure large quantities of ore vitally needed for the planned expansion of iron and steel production in Egypt, especially that these new deposits are the closest ever to be located to the Iron and Steel factory complex in Helvan.

The techniques used represent some of the most advanced technological developments where images gathered by modern electronic techniques from satellites and aircrafts were used.

Remote Sensing Project Director, Dr. Abdel-Hady, and Dr. El-Shazly, Director of the geological group in the project and Director of the Geology Dept. of the Atomic Energy Establishment both emphasized the significance of the discovery on the future development of the three governorates of El Fayoum, Beni Sweif and Menya, in which these deposits are located.

LANDSAT IMAGERY
BY BECHTEL, INC
(WORLDWIDE)

USE OF LANDSAT IMAGERY BY BECHTEL, INC. FOR ENGINEERING GEOLOGY

Introduction

The Geology group of Bechtel has routinely used aerial photography in our field investigations since the group started. We began using satellite imagery as soon as it was made available to the public, and in 1973, our usage increased to the point where it became necessary to set up a standing account with EROS Data Center. Since January, 1974, we have ordered $3,000 worth of imagery through our standing account. We order a variety of products from EROS, but the following discussion deals only with our usage of ERTS-LANDSAT imagery.

Applications

Bechtel's Geology staff provides geological services to the Bechtel Group of Companies both in the U.S. and worldwide. We perform engineering geology investigations for a variety of construction projects, including nuclear and fossil fuel power plants, dams and hydro-electric projects, highways, pipelines, industrial complexes, airports, telecommunications projects, mining facilities, etc.

Depending on the type of project, the geographic area involved ranges from a few acres to hundreds of square miles. Often, it takes only one LANDSAT scene to cover a project area and at other times (particularly with pipeline or highway routes) the project may require as many as fifty. Since the beginning of 1975, our project work has shifted emphasis from domestic areas to foreign countries. This means that LANDSAT imagery has

become even more vital to us, since LANDSAT imagery is often the only type of imagery readily available for a foreign area.

We still rely on visual interpretation of our satellite imagery. We feel that automated enhancement and classification programs are not yet cost effective for our geological project work. Remote sensing investigations are just one tool that we use in our engineering geology investigations, and there isn't justification to spend the money or time required by these programs, for just one phase of our work.

We use LANDSAT imagery in three different ways: for presentation purposes, for derivation of data from the images, and for reconnaissance work.

LANDSAT imagery is used often for client presentations and project meetings. It seems to impress people and has an immediate impact. Mosaics are often constructed (for a multi-image area) and sites are labeled on it. It is very useful for orienting people, and in pointing out geomorphological features.

When projects require it, we do lineament studies of LANDSAT imagery, that is, we use the imagery to derive geological data. Lineaments are objectively located on the imagery, then are compared with topographic, geologic, structural and hydrogeologic maps to check for correlations with various features. Those lineaments representing cultural features are eliminated, and the remaining lineaments are usually

related to geological features in some way. Lineaments can sometimes be the surface manifestation of faults, so suspicious lineaments are field checked whenever possible. Lineament studies are most useful to us in analyzing the geologic structure of an area.

We also use LANDSAT imagery for reconnaissance geologic work. Examining LANDSAT imagery in the preliminary stages of a project can help to narrow down the field reconnaissance to specific areas, and so saves field time. It helps us in locating large outcrops (on a regional basis) or at least open terrain. Areas of lineament intersections may indicate specific problem areas to be investigated.

Product Statistics

The attached table shows the types of products we have ordered since 1974.

The 1:500,000 is the most workable scale and is most often used for lineament studies. We also use the 1:1,000,000 scale heavily, but this is usually when we are working with a mosaic of many LANDSAT images.

Af first we routinely ordered one scene in each band, but we've found over a period of time that bands 4 and 6 were not really that helpful to us, and so we currently order bands 5 and 7 only. Our use of color has increased, largely due to the increased use of LANDSAT for presentation purposes. For derivation of data and geological comparisons,

b and w bands 5 and 7 are slightly more useful.

The table also shows the total spent each year on imagery. In the first half of this year, we have already spent an amount nearly equal to annual expenditures of the previous year. We are ordering more imagery and we anticipate this trend to continue.

Limitations of Data

Unfortunately, LANDSAT imagery cannot be used in direct geological mapping. No direct correlation can be made between geological formations and tonal signatures on the imagery. Geological features express themselves in a wide range of the electromagnetic spectrum, including the thermal infrared and radar bands. The current 0.5 - 1.1 μm doesn't yield much direct geological information; it is more suited to agriculture-forestry applications.

The resolution of LANDSAT also creates problems for geologists. We can only use LANDSAT for regional studies; the 60 km resolution prevents us from using it for site-specific geological investigations.

The lack of stereo creates problems in identifying terrain features, and in locating linear features.

Our Future Needs

In terms of available coverage, the quantity and quality of coverage of foreign areas needs to be increased. Our future work will require

more extensive studies of foreign areas.

Also, if turnaround time from EROS Data Center could be improved, it would facilitate more efficient use of imagery, and would better meet the demands of our often hectic work schedule.

Suggested Improvements

Expansion of the spectral sensitivity to include a thermal infrared and radar band would increase geologic applications. Also, increased resolution in these and existing bands would enable us to use imagery in more site-specific investigations. Addition of stereo would make it much easier to use LANDSAT for geologic purposes.

TABLE I

	1974	1975	1976 to date
Total Purchased	$1044.00	$995.00	$845.00
	# SCENES	# SCENES	# SCENES
SCALES			
1:250,000	2	5	3
1:500,000	61	26	20
1:1,000,000	3	80	16
1:3,369,000	0	20	0
BANDS			
4	0	5	0
5	16	38	13
6	13	31	1
7	36	37	10
Color	6	20	17

Telespazio

s.p.a. per le Comunicazioni Spaziali

Il Vice Direttore Generale

Roma, 4 agosto 1976

Dear Mr. Frutkin,

as an entity participating in the Landsat programme we had opportunities in the past to discuss with you the future of the Landsat programme and the importance of providing the community of users with a continous flow of satellite data.

The extensive life of Landsat 1 and 2 and the advanced progress on Landsat C are certainly very encouraging developments as they provide a more solid background than originally expected to our effort in the earth segment of this experimental programme.

In our current planning we regard Landsat C as a completion of the experimental phase when the satellite data have proved to be professional tools and moreover models and algorithms have been developed for interaction with other sources of data and for final information extraction.

Then Landsat D, now envisaged for the first half of 1981, with a higher resolution and an advanced thematic mapper , can regarded as the first truly operational satellite. Consequently also the work done in the previous phase will have to be up-graded to reach an operational level and quality, thus completing the effort of all involved.

This scheme is particularly applicable to the management of the renewable resources and mainly to agricolture where the general attention has already focused.

I thought of sharing these thoughts with you about the continuing interest we are placing on Landsat D programme and to confirm how much we would appreciate it to be kept abreast with any new development in the technical and economic definition of it.

I will be glad to enlarge on this subject at the next suitable occasion either in Washington or over here.

Cordially yours,

Piero Masarati

(Pietro Masarati)

Mr. A. Frutkin
Assistant Administrator
for International Affairs

The World Bank / 1818 H Street, N.W., Washington, D.C. 20433, U.S.A. • Telephone: (202) 393-6360 • Cables: INTBAFRAD

July 19, 1976

Mr. J. Zimmerman
Deputy Director
International Affairs Department
National Aeronautics and
Space Administration (NASA)
Washington D.C. 20546

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Dear Jim:

With the recent publication of the LANDSAT Index Atlas of the Developing Countries of the World, which I am attaching, I thought I would also bring you up-to-date on some of the major World Bank activities involving Landsat data. The Atlas was published by the two Divisions in the Bank, the Cartographic Division of the Administrative Services Department and the Economic and Resources Division of the Agriculture and Rural Development Department which are now utilizing NASA's imagery on a daily basis. It will be translated into French, Spanish, Arabic and e widely distributed overseas to facilitate the user in ordering tapes or imagery and to help make the developing countries more aware of existing coverage. Although 1,500 copies were printed only a week ago requests for more than that amount have already been received and a second printing has been ordered. Incidentally, a large portion of the demand orginates from the U.S. Government or International Agencies.

In addition to the index atlas the final draft manuscript copy of The Uses of Remote Sensing Systems in Developing Projects, a manual, funded by the Director's Office, has been completed and should be ready for publication and distribution within the next few months.

More specifically, LANDSAT information has been used extensively in agricultural projects. To cite one case, that of the State of Orissa, India, a land use map was made by processing computer tapes of thirteen landsat scenes of the wet season (November 1975) just prior to the harvest of the main rice crops. This imagery was then compared to the dry season coverage taken previously and measurements were made of paddy acreage under cultivation for comparison to agricultural statistics for the region. The investigations are directly related to the Bank's Eastern Region Food Grain Project and results of the analysis will have a direct bearing on the emphasis given to convert specific single cropping areas in the State to double cropping as well as to assist in the development of a better water management program for irrigation systems in the delta of the Mahanadi River.

It might be of interest to note that since completion of the land use investigations in Orissa, a request has been made by the State to do 'edge enhancement' ocessing for geologic and hydrologic investigations (also paid for out of national unds) which complement the computer categorization done previously for land use.

(A similar request has also been made that the UNDP/Bank project in Burma be expanded to include such other sectors along with the scheduled land use classification.

The cost and time required to make the Orissa land use map was approximately 4 man-months - including groundtruthing operations. In Bangladesh a similar land use map prepared by the FAO took approximately 330 man-years for an area of almost identical size. While the time difference to make the land use map is most remarkable it should be noted that the eleven year FAO-Bangladesh Land Use Mapping project also provided additional detailed soils and land capability data which is not possible through landsat imagery analysis. However, in the case of Bangladesh which had soil/land use maps available for comparison, the land use information was actually much more detailed and up-to-date on the sample area done than was the FAO map data. Thus, it becomes evident that not all types of data can be obtained from landsat, but some information can readily be obtained in a fraction of the time or costs of doing pure terrestrial survey operations backed by large-scale aerial photo coverage. Before long the final rendition of the Orissa wet and dry season imagery should be available and a copy of the mosaic will be sent to you along with information on the crop statistics on a District by District basis.

Staff from several Ministries and the National Remote Sensing Agency were involved in doing the land use mapping and field surveys. Preliminary results of the study indicate that the potentials of the landsat system have hardly begun to be utilized in development operations.

As a result of the above, India has begun to give serious thought to investment in equipment and processing facilities in this field. The Bank is also considering supporting an Indian request for the funding of a receiving /processing station.

With all of these positive developments come a few problems you should be aware of: Few countries indeed have undertaken tape analysis or have attempted to tie in imagery to ground surveys. The USAID as well as international agencies such as the Bank should stress the applications and cost saving aspects far more than they have in the past. To train national staff in sophisticated processing in the U.S. before they have even attempted to analyse existing imagery or tapes in the field is largely a waste of funds. The 'trainees' that prove themselves in field operations today should be the ones selected for more sophisticated training the the U.S. tomorrow and service contracts for processing of imagery by commercial firms with full expertise in this highly technical field is fully warranted and can fill the gap at this time until the equipment and staff overseas becomes operational. Equipment cost for the hardware and program cost of software, are being modified radically and are being reduced in price on almost a monthly basis as this rapidly changing technology advances.

While the India experience has provided the Bank with an excellent pilot case of the utility of Landsat imagery we are now expanding operations of this sort to include 15 scenes to be tape processed in Burma and 10 in Zaire at present and others are scheduled to be done for the Philippines, Thailand, Kenya, Tanzania in the near future. As these projects unfold I will keep you briefed but I did want to take this opportunity to bring you up-to-date on the publication of the index atlas, the manual and the status of the Orissa Project.